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Department of
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Forest Service
Southern Region

Certification Training
Applying Pesticides Correctly

A Self-Study Guide for
USDA Forest Service Employees

General Category

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INTRODUCTION

This booklet was prepared for Forest Service employees in the Southern Region to provide information on pests and their management for persons wanting to become certified pesticide applicators. This booklet will help toward that goal.

The self-study guide, "Safety Training for Forestry Herbicide Applicators," should be studied before starting this training; for a knowledge of the material in the applicator's handbook is required as a foundation for understanding the data in this booklet.

This is a self-study guide, that is, a true/false and multiple choice test follows each lesson. Answers to the test questions are provided immediately following each test. By taking the test after reading each lesson and then checking the answer, you will be reinforcing your knowledge of the text material. These tests will not be graded. Their purpose is to help you learn, therefore, there are not trick questions. You should, however, read each question carefully and select an answer with the same care to find the best answer.

At the beginning of each lesson is a list of terms you need to understand. The definitions of these terms are not provided there, but must be found in the glossary. This is another way to help you learn. If you write in your definition in pencil, then check the glossary and make any necessary corrections, you will be strengthening you understanding of these important words. Without a thorough understanding of these terms, you cannot fully comprehend the material in the rest of the lesson.

Be sure you have mastered each lesson before you go on to the next one. If you are doubtful about any points, go back and re-read the parts in question. Underline or make notes in the margins to help you find important facts. This is your workbook. Use it to your advantage to become a more knowledgeable, safer, and a more efficient user of pesticides.

This guide, along with classroom instruction will give you the factual material you need to know to use pesticides correctly and to earn your certification as a restricted-use pesticide applicator. Remember that you must exercise good judgement as well as possess factual information to work with pesticides safely and effectively.

Remember, too, that you are a public servant, using your abilities to foster good forest management for the benefit of all citizens. Courtesy toward all members of the public, and a sincere effort toward understanding their needs and wishes are as important as technical competence. No matter what your position, to the public you <u>are</u> the Forest Service. As you continue to study, you will be continuing a proud tradition of service to your community and to your Nation.

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LESSON 1

INTRODUCTION TO PESTICIDES

A. INTRODUCTION

Pesticides are chemical substances or biological organisms used to control pests. They are useful and necessary tools to maintain the standards of quality we have come to expect within our society. They help the farmer to produce abundant, high quality products, help to control diseases that have a direct influence on our health, and help protect our homes, lawns, and gardens. Forest owners and managers must cope with many insects and diseases, weeds and other plants that compete with desirable trees for food, water, and sunlight. These pests are an ever-present problem from a tree's seedling stage through maturity. Yet pesticides are not without disadvantages. They are expensive, and must be used with care to assure the safety of the user and the environment. Pesticides include:

-- chemicals used to kill pests (including plants)

-- chemicals used to attract or repel pests, and

-- chemicals used to regulate plant growth, or to remove the leaves.

B. TERMS YOU NEED TO UNDERSTAND

How well do you know some of the terms that are important in the use of pesticides? Test your knowledge of them by writing down the definitions for the terms below. To check your answers, refer to the glossary.

1. Pesticide

2. Inorganic

3. Organic

4. Systemic

5. Phytotoxicity

6. Adsorption

C. DISCUSSION

Here are some of the things you should know in order to choose the right pesticide and use it most effectively.

Pesticides are chemicals used to destroy, prevent, repel, or control pests. Seventeen of them are listed below. They are used for the pests as indicated.

Insecticide: Insects

Miticide: Mites.

Acaricide: Mites, ticks and spiders.

Nematicide: Nematodes.

Fungicide: Fungi.

Bactericide: Bacteria.

Herbicide: Plant.

Rodenticide: Rodents.

Avicide: Birds.

Piscicide: Fish.

Molluscicide: Mollusks, such as slugs and snails.

Predacide: Vertebrate pests, such as weasels, foxes, etc.

Repellent: Keeps pests away.

Attractant: Lures pest.

Plant growth regulator: Stops, speeds-up or otherwise changes normal plant growth.

Defoliant: Removes unwanted plant leaves without killing the whole plant immediately.

Desiccant: Dries up plant leaves and stems, and insects.

THE NATURE OF PESTICIDES

Pesticides can be grouped according to their chemical nature and how they work. Four groups of pesticides are reviewed in the following sections.

Chemical Nature

Inorganic Pesticides

These are made from minerals. Minerals of past use are arsenic, copper, boron, lead, mercury, sulfur, tin and zinc. Examples: lead arsenate, Bordeaux mixture, and Paris green.

Synthetic Organic Pesticides

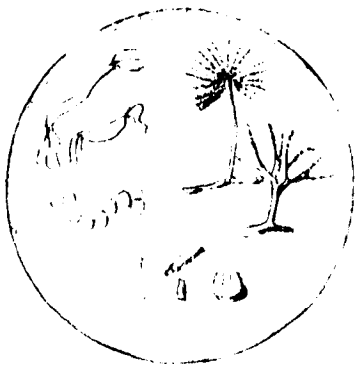
These are often referred to as man-made pesticides. They contain carbon, hydrogen, and one or more other elements such as chlorine, phosphorus, and nitrogen. Examples: 2,4-D, atrazine, captan, parathion, and malathion.

Plant-Derived Organic Pesticides

This category of chemicals is extracted or derived from plants or plant parts. Examples: rotenone, red squill, pyrethrins, strychnine and nicotine.

Living Organisms

These include bacteria, fungi, animals and birds. None of these are manufactured. They are organisms that can be manipulated.



HOW PESTICIDES WORK

Pesticides can also be grouped according to what they do. Read the label to find out what each pesticide will do. The major groups are --

Protectants: Applied to plants, animals, structures, and products to prevent entry or damage by a pest.

Pest Sterilants: Make pests unable to produce offspring.

Contacts: Kill pests by contact.

Systemics: Substance circulated in an animal's blood system or translocated within a plant.

Translocated herbicides: Kill plants when absorbed by leaves, stems, or roots; they move throughout the plant.

Fumigants: Gases that kill when they are inhaled or otherwise absorbed by the pest.

Anticoagulants: Prevent normal clotting of blood.

Selective: More toxic to some kinds of plants or animals than to others.

Nonselective: Toxic to most plants or animals.

Pheromones: Affect pests by changing their behavior.

Stomach toxicant: Kills when eaten or swallowed.

USING PESTICIDES

Pesticide labels contain many terms that describe when and how to use the pesticide. You should know and understand these terms. They will help you get the best results from your pesticide without harming you or the environment.

When To Use

Terms that tell you when to use the pesticide product --

Preemergence: Used before crops or weeds emerge.

Preplant: Used before the crop is planted.

Postemergence: Used after the crop or weeds have emerged.

Dormant spray: Used while the plant host is dormant.

How To Use

Terms that tell you how to use the pesticide product --

Band: Applied to a restricted strip over or along a crop row or on or around a structure.

Basal: Applied to stems or trunks at, or just above, the ground.

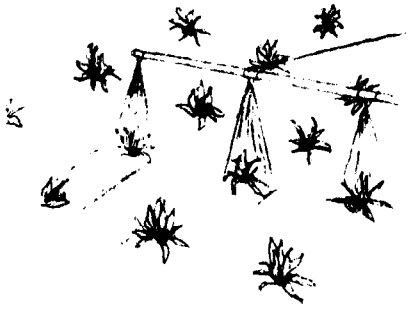
Broadcast: Uniform application over the entire treated area.

Crack and crevice: Applied in structures to cracks and crevices where pest may live.

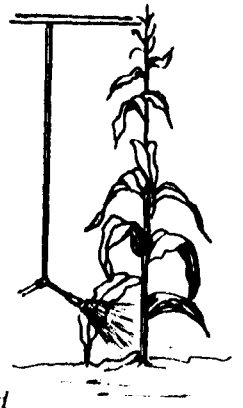
Dip: Complete or partial immersion of a plant, animal, or object in diluted pesticide.

Spot: Applied to a small area, such as over an individual plant.

Directed: Aiming the pesticide at a specific plant or a portion of a plant, animal, or structure.



Band



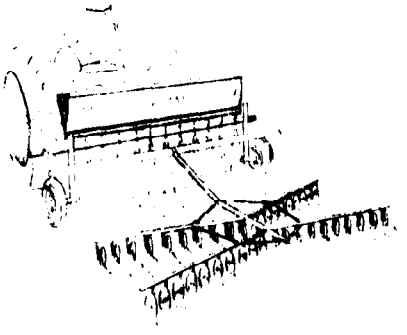
Directed

Foliar: Applied to the leaves of plants.

In-furrow: Applied to, or in, the furrow in which a plant is growing.

Over-the-top: Applied from above the growing crop (compare to sidedress and others).

Soil Application: Applied to the soil rather than to plants.



Soil Incorporation

Soil incorporation: Use of tillage implements to mix the pesticide with the soil.

Soil injection: Applied beneath the soil surface.

Accuracy Is Important

The rate and time of application of pesticides are critical. Pesticides work best when applied at specific times. Using them before or after the

correct time reduces or even eliminates their effectiveness. Correct timing may help reduce damage to nontarget species.

Because all these chemicals work in small amounts, be careful to treat only the intended target, and at the prescribed rate. Avoid getting them on anything else as a result of drift or of residue in application equipment or the soil.

FACTORS AFFECTING PESTICIDE ACTIVITY

Soil, Moisture and Rain

Organic matter in soils may limit some pesticide activity. Soils with a high organic matter content may need higher rates for good control. The soil texture may also affect the way pesticides work. Soils with fine particles (silts and clays) provide the most surface area. They may need higher rates especially for the soil-applied pesticide. Coarser soils (sands) have less surface area. Use lower rates on them. Follow the label instructions.

Soil moisture and rain affect the way some pesticides work, especially those applied to the soils (soil active). They also affect how long pesticides stay on the soil and plants. Most pesticides work best with moderate soil moisture. Excess rain can cause some soluble pesticides to leach more through the soil. Moderate rain is good when pre-emergence pesticides are applied to the surface. They are the carried into the soil to the pests. However rain during or soon after over-the-top or foliar applications may wash pesticides off the leaves.

Humidity and temperature also affect the way pesticides work. Most herbicides work best when plants are growing fast. High relative humidity and optimum temperatures usually contribute to this fast growth. High temperatures may reduce the activity of some pesticides. Low temperatures may also slow down or stop the activity of some pesticides. Check the label.

Light also affects the activity of some pesticides. Some effects on the target species may be sooner during sunlight, others sunlight may begin to break down the pesticide from exposed surfaces, reducing activity.

Pesticide Resistance

The ability of a pest to resist poisioning is called pesticide resistance. Consider this factor when planning pest control programs. Rarely does any pesticide kill all the target pests. Each time a pesticide is used, it selectively kills the most sensitive individuals; some avoid the pesticide, others are able to withstand its effects. Pests that are not destroyed pass along to their offspring the trait that allowed them to survive.

When we use one pesticide repeatedly in the same place, the insects there sometimes build up their resistance. Some pests have become practically immune to certain insecticides; however, most pesticide failure is not caused by pest resistance. Make sure you have:

-used the correct pesticide
-used the correct dosage, and
-applied the pesticide correctly.

PLANT GROWTH REGULATORS, DESICCANTS, DEFOLIANTS, AND ANTITRANSPIRANTS

Plant growth regulators, desiccants, defoliants, and antitranspirants change normal plant processes.

How They Work

Plant Growth Regulators

All plant parts are made up of tiny cells that continually multiply and grow. Plant growth regulators speed up, slow down, or

otherwise affect cell growth and reproduction.

Desiccants and Defoliants

Both materials are used to get rid of leaves, stems, and weeds. They are used on a limited basis to pretreat areas that are to be burned.

Defoliated Cotton

SELF TEST

AND

ANSWERS

LESSON 1

SELF TEST

1. Pesticides are chemicals used to control pests. Because of government regulations, which of the following are classed as pesticides:

   ____ a. Chemicals used to attract or repel pests.
   ____ b. Chemicals used to regulate plant growth.
   ____ c. Chemicals used to remove plant leaves.
   ____ d. Chemicals used to coat plant leaves.
   ____ e. All of the above

2. If you wanted to speed up or slow down the growth of seedlings you would use a:

   ____ a. Plant growth regulator
   ____ b. Desiccant or defoliant
   ____ c. Both of these

3. Match the following:

____ a. Avicide	1. Controls nematodes.
____ b. Nematicide	2. Controls predators or other pest animals.
____ c. Piscicide	3. Controls fish.
____ d. Predacide	4. Controls birds.

4. A pesticide most likely to be used to kill crawling insects would be:

   ____ a. A contact pesticide
   ____ b. A stomach poison
   ____ c. None of the above

5. A translocated herbicide:

   ____ a. Stays in one part of the plant
   ____ b. Moves throughout the plant
   ____ c. None of the above

6. Match these:

____ a. Attractant	1. Used to remove leaves from stems.
____ b. Repellant	2. Changes the rate of plant growth.
____ c. Defoliant	3. Keeps pests away.
____ d. Plant growth regulator	4. Lures pests.

7. The activity of a pesticide may be affected by:

   ____ a. Moisture, humidity
   ____ b. Texture of soil
   ____ c. Temperature
   ____ d. All of the above

8. Match these:

____ a. Contact pesticide	1. Makes pest unable to produce offspring.
____ b. Stomach toxicant	2. Is absorbed on plant leaves and travels to other parts.
____ c. Translocated herbicides	3. Gasses that kill.
____ d. Fumigants	4. Must be eaten to kill.
____ e. Sterilants	5. Kills when pest touches it.

9. Match the following:

____ a. Band	1. Applied to the leaves of plants.
____ b. Directed	2. Applied in the furrow in which a plant is growing.
____ c. In-furrow	3. Applied to a stem of a plant at or around the ground line.
____ d. Foliar	4. Applied to a small area.
____ e. Basal	5. Applied in a strip.
____ f. Spot treatment	6. Aimed at part of plant or animal.

10. Match the following:

____ a. Preplant	1. Use after crops and weeds have emerged.
____ b. Pre-emergence	2. Use before crops or weeds have emerged.
____ c. Post-emergence	3. Use before crop has been planted.

11. Injury to plants as a result of a pesticide application is called:

____ a. Morphosis
____ b. Phytotoxicity
____ c. Spondylitis
____ d. Photolysis

12. Soils with fine particles, such as silts and clays, may need _____ rates, especially when soil-active pesticides are used.

____ a. lower
____ b. higher
____ c. same

13. Match the following:

____ a. Adsorption	1. Chemicals held on the surface of soil particle.
____ b. Absorption	2. Contains carbon.
____ c. Organic	3. Chemical taken into plants or animals.

ANSWERS - LESSON 1

1. e

2. a

3a. 4
b. 1
c. 3
d. 2

4. a

5. b

6a. 4
b. 3
c. 1
d. 2

7. d

8a. 5
b. 4
c. 2
d. 3
e. 1

9a. 5
b. 6
c. 2
d. 1
e. 3
f. 4

10a. 3
b. 2
c. 1

11. b

12. b

13a. 1
b. 3
c. 2

LESSON 2
TOXICOLOGY
PART 1: INTRODUCTION TO TOXICOLOGY

A. INTRODUCTION

Toxicology is the science that studies the harmful effects of chemicals. It is a young science compared to its parent discipline pharmacology, the science that studies all effects of chemicals, with particular emphasis on medicinal effects.

B. TERMS YOU NEED TO UNDERSTAND

How well do you know some of the terms that are important in the understanding and use of pesticides? Test your knowledge of them by writing down the definitions for the terms below. To check your answers, refer to the glossary.

1. Toxicology

2. Natural Chemical

3. Synthetic Chemical

4. Biochemical

5. Foreign Chemical

6. Sensitization

C. DISCUSSION

CHEMICALS - EVERYTHING

Everything in our world is chemical. All matter (everything) is composed of elements. An element may be representative of a single atom or of many of the same kind of atoms. About 90 kinds of stable elements are found in nature, and only about 15 other mostly unstable ones exist. The natural elements are the basic building blocks for substances we come in contact with during everyday life.

NATURAL AND SYNTHETIC CHEMICALS

All chemicals fall into two major categories: natural (made by natural processes) and synthetic (made by man). Many chemicals fall into both groups -- they are found in nature and they can be made (synthesized) in the laboratory or factory. However, some chemicals have not been made in the laboratory. Also some synthetic chemicals are not found in nature.

Chemicals that come from plants or animals are called biochemicals. They may also be produced in the lab or factory, and are then called synthetic. A chemical that is biochemical benefiting one group of organisms may be foreign, not benefiting or deadly, to another group. For example, strychnine is a beneficial chemical in certain plants and a foreign and deadly chemical for animals. Some people think that natural chemicals are "good" and man-made chemicals are "bad". However, plants and animals are not harmed, or helped, on the basis of the chemical's origin -- nature or the laboratory. The laws and principles of toxicology and pharmacology apply equally to all chemicals -- whether they are natural or synthetic, biochemical or foreign.

USAGE OF CHEMICALS -- THE BASIS OF REGULATION

Under our laws, chemicals are categorized by use, not their toxicity. Chemicals associated with foods are regulated by food laws, chemicals used as drugs by drug laws, chemicals used as cosmetics by cosmetic laws, etc. For example, boric acid is regulated as a drug when used as an antiseptic eye wash, as a household product when used in laundry detergents, as an insecticide when used to kill roaches, as a herbicide when used to kill weeds, and as a flame retardant when used to fireproof fabrics. The toxicity of a chemical is totally independent of the category in which it is placed.

Most of these chemicals evoke a positive feeling about their use because they enhance, soothe, clean or serve another nondestructive purpose. In contrast, chemicals used as pesticides are more likely to be feared by the public. Fear probably arises because these chemicals are used to kill their target (insects, rodents, weeds, etc.). Moreover, the news media give a tremendous amount of attention to the use and misuse of pesticides. Some people mistakenly believe that all pesticides are very highly toxic chemicals. The fact is that many pesticides are no more toxic than some other chemicals that we use every day. A number of chemicals that are used as pesticides are also used for other purposes, such as drugs or industrial chemicals. Boric acid is an example, as mentioned earlier.

ADVERSE EFFECTS OF CHEMICALS

Chemicals may harm us in a number of different ways. Some may explode, ignite, destroy tissue (if they are corrosive), or they may injure tissue because of their irritant properties. Some chemicals cause sensitization (allergic) reactions. Other chemicals may have harmful toxic properties. Some chemicals possess only one harmful property, and others two or more.

HAZARDS AND TOXICITY

The word "hazard" is commonly misused to mean "toxicity". A hazard is much more complex -- it refers to the chance that a chemical will be harmful. A hazard is made up of two components: 1) the basic ability of a chemical to do harm, and 2) the ease with which it may come in contact with the object of concern (e.g., people, trees, wildlife).

The toxicity of a chemical refers to its ability to do systemic damage -- this kind of damage takes place somewhere else in the body or a plant other than the point of contact. For example, when some chemicals are absorbed through the lungs, damage to the kidneys will result. If the chemical is eaten, damage to the liver may result. The toxicity of chemicals is the subject of this part of the study guide.

A. INTRODUCTION

All effects of chemicals, whether they be beneficial, neutral, or harmful, depend on a number of conditions. For example, how much chemical one is exposed to, how often the exposure occurs, how the chemical gets into the body (by mouth, skin, lungs, etc.), the kind (species) of animal or plant that is exposed, its age, sex, state of health and nutrition, and whether or not other chemicals are present that might alter the effect.

B. TERMS YOU NEED TO UNDERSTAND

How well do you know some of the terms that are important in the understanding and use of pesticides? Test your knowledge of them by writing down the definitions for the terms below. To check your answers, refer to the glossary.

1. Dose-Time Relationship

2. Acute Toxicity

3. Chronic Toxicity

4. Antagonism

5. Adaptation

C. DISCUSSION

HOW MUCH - HOW OFTEN

This combination of "how much" and "how often" is known as the dose-time relationship. The dose is the quantity of a chemical that a living creature gets at one exposure. Time refers to how often the exposure occurs. The amount of chemical (dose) may be very large, such as when a chemical accidentally spills during transportation or during a work accident. The amount of chemical (dose) could also be very small, such as exposures to trace amount of pesticide residues that may be in foods. Sometimes the exposure is only once, such as an accident. The exposure could also be repeated over and over again for long periods of time, as in residues in foods. There are many combinations of "how much" and "how often." A person may be exposed only once to a fairly large amount of pesticide, at one extreme. Another person may have a lifetime exposure to very tiny amounts, at the other extreme.

No one can study every possible combination of dose and time, so toxicologists study the effects that occur at the two extremes. Then they judge what might happen with all the intermediate combinations of dose and time. Of all of the factors that influence toxicity, the dose-time relationship has the greatest bearing on whether or not a chemical will be harmful.

Because of the influence of "how much" and "how often", we must distinquish between acute and chronic toxicity. Acute toxicity refers to the effects from a one-time exposure. Chronic toxicity refers to the effects from long-term exposure. Acute toxicity and chronic toxicity are the subjects of later parts in this study guide.

As we will see, some chemicals may be acutely toxic and chronically nontoxic. And some chemicals are just the opposite -- acutely nontoxic and chronically toxic. However, most chemicals have some degree of both acute and chronic toxicities. Regardless of which group a chemical fits, it is extremely important to remember the exposure conditions. Every chemical is harmless under some exposure conditions. Conversely, under some conditions the chemical is harmful. Later lessons will help to explain these conditions.

ROUTE OF EXPOSURE

The route of exposure refers to the place through which a chemical enters the body. After the dose-time relationship, the route of exposure is the most important factor in determining whether or not a chemical will be harmful. Chemicals enter the body via three major places: mouth (oral), lungs (inhalation), and skin (dermal).
Chemicals can also be injected in the skin or into a vein. These routes are only used by physicians or in cases of drug abuse. They are not usual pathways of exposure for the average person. Thus, they will not be considered here.

The toxicity of a chemical can vary greatly, depending upon its pathway of entry into the body. Chemicals are absorbed to different degrees at the different routes; if a chemical can't get into the body, it can't do any harm!

Exposure by Mouth

We may consume chemicals with our food or drink. This is called the oral (or ingestion) route. People who work with chemicals may mistakenly believe that ingestion is not important -- they do not eat the chemicals! However when people do not wash their hands after handling a chemical and before smoking or eating lunch, the chances are good that they will ingest some of the chemical.

Ingested chemicals are absorbed primarily through the intestines. The intestines are designed to absorb foods and sometimes cannot distinguish between foods and nonfoods. Only the lungs permit greater absorption of some chemicals than the intestines.

Exposure via Lungs

Some chemicals may get into our bodies through the lungs. We breathe in the chemical if it is mixed in the air around us. This is called the inhalation route. As a general rule, chemicals are absorbed to the greatest degree through the lungs. We are most likely to inhale volatile chemicals, -- those which vaporize readily, or chemicals that create fine dust particles because they must be in the air to be breathed into the lungs.

Lung surfaces are very, very thin membranes that offer a poor barrier against the entry of chemicals into the body. These membranes allow for easy passage of oxygen into the body. They also serve as an exit for carbon dioxide from the body. These membranes permit easy passage of most gases and vapors. You should be aware of one exception -- pesticides of low volatility. Because of this low volatility most forestry used pesticides or the low amount of fine particles in the dry formulations, and the way our pesticides are applied, dermal exposure is a greater risk than inhalation.

Exposure via the Skin

Some chemicals can be absorbed through the skin. This pathway is called the dermal route. The skin is the best barrier against the entry of chemicals into the body. One of the functions of the skin is to keep us from drying out. Because the skin forms a barrier against loss of liquids and solids, it also forms a barrier against entry of liquids and solids. If this were not true when we go swimming we would fill up with water like a sponge. As a general rule, liquids penetrate the skin more easily than solids, and oily liquids or oil-soluble liquids penetrate the skin more easily than watery ones.

MOVEMENT FROM POINT OF EXPOSURE

The previous section presented the routes of exposure that affect toxicity. Toxicity also depends on the pathway a chemical takes after it enters the body. Most chemicals that reach the intestines are carried on to the liver before going to the rest of the body. In contrast, chemicals that enter through the lungs or the skin go directly to all parts of the body before eventually going to the liver.

The liver is the great processing plant of the body. It chemically changes many chemicals that enter it. If the chemical change converts the chemical into one that is less toxic, passage through the liver protects the body. In this case the chemical would be less toxic by the oral route than by the dermal or inhalation routes. (We can assume that the degree of absorption is the same for all three routes.) If the chemical changes in the liver to a more toxic form passage through the liver would be harmful. In this case, the oral toxicity would be greater than the dermal or inhalation toxicities.

In summary, the toxicity of chemicals can vary with the route of exposure: acute oral, acute inhalation, acute dermal, chronic oral, chronic inhalation, or chronic dermal toxicity. Every chemical has six kinds of toxicity!

SPECIES

A great deal is known about how toxicity varies with the kind of animal exposed. Most of this information comes from experiments on animals. All kinds of animals have been used in toxicity experiments: rats, mice, hamsters, guinea pigs, rabbits, dogs, cats, chickens, miniature pigs, monkeys, etc. The list of chemicals that have different toxicities for

different species is very long. And the ranking of species for their susceptibility to chemicals varies with chemicals. There is no one species for which all chemicals are most toxic, second most toxic, and so-forth down to least toxic. If there were, chemicals could be tested more easily. Humans would then always fit at the same points in the list. Tests would involve only one animal species that was more susceptible than humans to the toxic effects of chemicals. Instead, we must study each chemical in different species to obtain data that can be translated to humans. In the translation, we always assume that humans are more susceptible than animals -- which is not generally true.

AGE

Animal tests and our experience shows us that some chemicals are more toxic to infants than to adults. Conversely, some chemicals are less toxic to infants than to adults. These differences probably result from the way the liver processes chemicals. Babies have immature livers. A baby's liver cannot detoxify the chemical efficiently, or at all. For example, if the adult liver converts a chemical to a less toxic form, then this chemical would be more toxic to infants, because the immature baby liver cannot make the chemical less toxic. The opposite would be true if the adult liver converted the chemical to a more toxic form. We know little about the effect of age on toxicity of chemicals. Therefore, we always assume that infants and the elderly are more susceptible than most adults to the adverse effects of chemicals.

SEX

Animal tests show that some chemicals have different toxicities for males and females. Some chemicals are more toxic to males and some are more toxic to females. We know almost nothing about whether this difference occurs in humans.

NUTRITION

Research indicates that nutrition plays an important role in whether or not chemicals will be harmful. A diet adequate in proteins and vitamins protects against the harmful effects of some chemicals.

STATE OF HEALTH

As with nutrition, physical and emotional good health appear to protect us, either directly or indirectly, against the harmful effects of chemicals. However, we need more research on this subject. At this time, one's state of health has little practical application in the field of toxicology.

INDIVIDUAL SUSCEPTIBILITY

Some studies show that certain inherited traits affect one's response to chemicals. For example, a person may suffer more adverse effects than do other people from certain chemicals or classes of chemicals. That person's chemical genetics were responsible. Even among people who are apparently average, individual differences do exist. For this reason, the amounts of chemicals that could be toxic are given as averages rather than absolute values.

CHEMICAL COMBINATIONS

Sometimes chemicals in combination are more -- or less -- harmful than either chemical alone. When they are more toxic the effect is called synergism. When they are less toxic the effect is called antagonism. Perhaps the best known synergistic effect is the great increase in the toxicity of some tranquilizers when taken with alcohol. Otherwise, little is known about these effects.

ADAPTATION

Adaptation involves repeated exposures to small amounts of a chemical. A person becomes tolerant to larger quantities of the chemical over a period of time. Otherwise the chemical would be harmful.

LESSON 2
TOXICOLOGY
PART 3 - ACUTE TOXICITY

A. INTRODUCTION

Acute toxicity is the ability of a chemical to harm a person, animal, or plant after only one short exposure. The harm that is done occurs someplace else than at the point of contact with the chemical. This distant, or nearby site of damage distinguishes toxic from corrosive effects of chemicals. Corrosive chemicals will damage structures and tissues that they actually touch. In contrast, toxic chemicals do damage somewhere else in the body. They might damage an organ, such as the liver or kidneys, or they might upset some processes in your body, such as those that produce blood cells. Some chemicals are only corrosive, some are only toxic, and a few others are both corrosive and toxic.

B. TERMS YOU NEED TO UNDERSTAND

How well do you know the terms that are important in the understanding and use of pesticides? Test your knowledge of them by writing down the definitions for the terms below. To check your answers, refer to the glossary.

1. LD 50

2. LC 50

3. Poison

4. Milligram (mg)

6. Kilogram (kg)

7. Meter

8. Liter

C. DISCUSSION

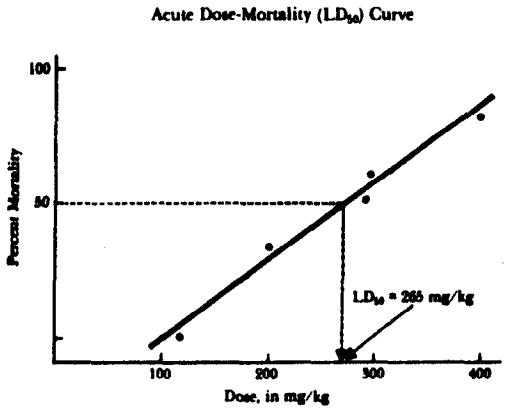
A great deal is known about the acute toxicity of chemicals because this type of harm is fairly easy to study in the laboratory. We also, unfortunately, know a lot about acute toxicity in humans from accidental exposures and from suicides.

ACUTE ORAL TOXICITY

The acute oral toxicity of chemicals is found by giving several groups of animals increasing doses of the chemical. Ideally, the smallest dose will kill none of the animals and the largest dose will kill all of the animals. The animals are observed for 14 days, during which time deaths are recorded. At the end of the test, the dose that would kill 50 percent of the animals is calculated. This dose is known as the LD 50. LD means "lethal dose" and the "50" pertains to 50 percent of the animals tested.

ACUTE DERMAL AND INHALATION TOXICITIES

Acute dermal and inhalation toxicities are determined in a manner much like that for acute oral toxicity. However, the chemical doses are applied to the animals' skin or inhaled by them in special chambers. In this manner, the LD 50 is obtained for acute dermal toxicity. The amount of chemical fumes inhaled is measured as a lethal concentration (LC). The acute LC 50 corresponds to the acute LD 50. Acute dermal and inhalation toxicities of chemicals are much more important to you than are oral toxicities. You are more likely to get chemicals on your skin or inhale the vapors or dusts than to be exposed to them in your food or drinks.



CRITICAL MEASUREMENTS

Oral and dermal LD 50 are measured in milligrams (mg) of chemical per kilogram (kg) of body weight of an animal (mg/kg). Three ways are used to express inhalation LC 50:

-- mg of chemical per cubic meter (m^3) of air (mg/m^3)
-- mg of chemical per liter (L) of air (mg/L)
-- parts of chemical per million parts of air (ppm).

Highly Toxic

-- Oral LD 50 = 50 mg/kg or less
-- Dermal LD 50 = 200 mg/kg or less
-- Inhalation LC 50 = 2 mg/L of dust
-- Inhalation LC 50 = 200 ppm of gas or vapor
-- Chemicals in all four groups above must carry a "poison" warning on the label.

Toxic

-- Oral LD 50 = 50 to 5,000 mg/kg
-- Dermal LD 50 = 200 to 2000 mg/kg
-- Inhalation LC 50 = 2 to 200 mg/L of dust
-- Inhalation LC 50 = 20,000 of ppm of gas or vapor

Nontoxic

All LD 50 and LC 50 readings higher than those above. Remember -- the higher the number, the more chemical required to injure or kill the victim. The lower the number, the less chemical required to injure or kill.

Although a chemical may be legally nontoxic, it could be harmful under some conditions. Treat all chemicals with care.

Remember: we do not know the LD 50 or LC 50 of any chemical for humans. These values are based on data from tests on animals. Obviously, such experiments may not be performed on humans. Instead, average lethal doses (ALD) for humans are estimated from data on animals and human experience. The smallest LD 50 obtained by animal tests is multiplied by the weight of the human, in kilograms (kg). A chemical with an oral LD 50 of 10 mg/kg would be calculated to have an oral ALD of 100 mg for a 10 kg (22 pound) child, and 700 mg for a 70 kg (154 pound) adult. Although ALDs are of some value in estimating actual toxicity in humans, our real interest is in what might be an LD 0 (total dose for no people) for humans. We do not want to permit exposures that will kill any humans, much less half of them!

Fortunately, in almost all cases of mild acute poisoning, and even in many cases of severe poisoning, if the person survives the first 24 to 48 hours, recovery is complete and health restored.

A. INTRODUCTION

Chronic toxicity is the ability of a chemical to harm to a person, plant or animal upon repeated exposure. These exposures take place over long periods -- perhaps even a lifetime. As with acute toxicity, the victim is harmed at a place other than the point of contact.

B. TERMS YOU NEED TO UNDERSTAND

How well do you know some of the terms that are important in the understanding and use of pesticides? Test your knowledge of them by writing down the definitions for the terms below. To check your answers, refer to the glossary.

1. No-effect Level

2. Threshold

3. 100-Fold Margin-of-Safety.

C. DISCUSSION

Very little is known about the chronic toxicity of most of the chemicals we work with, except for those that somehow get into our foods. Tests on chronic toxicity take a long time and are expensive.

FDA TESTING

The Food and Drug Administration (FDA) requires testing of chemicals that may come in contact with foods. These chemicals must be given extensive tests for chronic oral toxicity. Three main groups of chemicals are involved. First are the additives -- food colorings, preservatives, emulsifiers, etc. The second group consists of the pesticides. The third group involves chemicals that are not intended to be in contact with food, but which might get on some food. For example, the oil in machines used to handle foods might get on some of the food. Such oils would be subject to testing for chronic oral toxicity. Because of these tests, those of use who use pesticides in our work know more about their safety than do industrial workers who handle chemicals.

EPA TESTING

The Environmental Protection Agency (EPA) regulates all industrial and environmental chemicals, including pesticides used in forestry. The chemicals are given several kinds of tests. One type of test is given for chronic toxicity. Other tests are given to see if the chemical may cause reproduction defects, changes in genes, or cause cancer.

Chronic toxicity studies require long-term or lifetime exposure of groups of animals to low levels of chemicals. As with acute toxicity testing, the lowest level of chemical exposure is one that will produce no detectable adverse effect in any of the animals. The highest level of chemical exposure is one that will produce significant adverse effects in some or all of the animals. During the feeding period and at the end of the experiment, the animals are subjected to many examinations and tests.

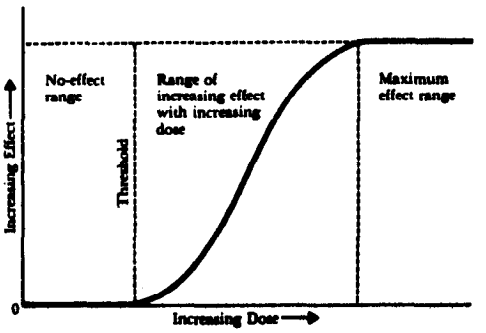
NO-EFFECT AND THRESHOLD EXPOSURES TO CHEMICALS

There is no neat expression like the LD 50 for acute toxicity that can be applied to chronic toxicity. Instead, we use terms such as no-effect level and threshold. The no-Effect level is that exposure level that produces no chronic effect in any of the test animals. The units of the no-effect level usually are parts of chemical per million parts of food, water, or air (ppm).

The threshold is the turning point between no-effect and effect levels. Thresholds exist because, our bodies can handle very small chronic exposures of some potentially harmful chemicals. The body may eliminate the chemicals or convert them to a less harmful form before any harm occurs. As the exposure increases, the body's ability to handle the chemicals becomes overwhelmed. Adverse effects then begin to appear. Finally, at high enough concentration, severe illness or death occurs.

The threshold concept shows the potential harm or safety of our exposure to trace amounts of industrial or environmental chemicals. If there were no thresholds -- levels below which chemicals would not be harmful -- we could not tell what risks, if any, we faced when we used a chemical. Despite the importance of the threshold concept, thresholds are not absolute values. They vary from species to species, and even among individuals within a species. Even though this is true, we may still use thresholds with a fair degree of confidence.

Dose-Response Curve



MARGIN OF SAFETY

Does a chronic toxicity test on an animal have the same results on a human? Rather than take a chance, we provide a 100-fold margin-of-safety. This margin assumes that we are 10-times more sensitive than animals to the chemical in question. For further safety, young, old, and ill people are assumed to be 10 times more sensitive than healthy adults. Thus, if the no-effect level of a pesticide was found to be 100 ppm, the maximum amount of residue that could result in human food would be 1 ppm.

Chronic adverse effects are dose-related; the greater the dose, the greater the effect. The adverse effects of chemicals are not random. They do not cause one set of symptoms in one person and an entirely different set in another. They may cause different sets of symptoms in different species, but within a species, their effects are predictable.

LESSON 2
TOXICOLOGY
PART 5 - THE GENS -
MUTA, TERATO, AND CARCINO

A. INTRODUCTION

Mutagenesis, teratogenesis, and carcinogenesis are grouped together in this lesson because the latter two are related, at least in some instances, to the former. Genesis means "to give rise to", muta means "change", terato means "monster", and carcino means "crab (cancer)". Thus, mutagenesis means to give rise to changes (mutations) in the genetic material of cells. Teratogenesis means to give rise to monsters (deformed fetuses). Carcinogenesis means to give rise to cancer. All three subjects are much too complex to cover in detail here. This lesson gives a brief overview of the relationship between chemicals and the "gens".

B. TERMS YOU NEED TO UNDERSTAND

How well do you know some of the terms that are important in the understanding and use of pesticides? Test your knowledge of them by writing down the definitions for the terms below. To check your answers, refer to the glossary.

1. Mutagenesis

2. Mutagen

3. Teratogenesis

4. Teratogen

5. Carcinogenesis

6. Carcinogen

7. Benign tumor

8. Malignant tumor

C. DISCUSSION

MUTAGENESIS

All living cells contain a chemical called DNA. DNA carries a code that contains all of the messages that each cell needs to reproduce itself exactly. The DNA tells the cell that it is a rat cell, a dog cell, a human cell, a male or female cell, a kidney cell, a liver cell, etc. Mutations are changes in one or more messages in the DNA structure. Physical or chemical agents that give rise to mutations are called mutagens.

A mutation may be so minor as to make almost no difference to the cell. The cell still functions and reproduces as it was designed to do. At the other extreme, the mutation may be so severe that the cell dies and disappears. Some mutations are severe enough to change a cell's identity, but do not kill the cell. Such cells might grow and proliferate as a tumor. In this event a cancer may result.

A mutation may occur in a cell in the skin, kidney, liver, etc. Mutations can also occur in reproductive cells (eggs or sperm). A mutation in a body cell may cause a tumor, but it cannot be inherited. A mutation in a reproductive cell can be inherited if that cell unites with a counterpart and develops into a new individual. In that case, the mutation will be inherited by all future progency. Depending upon the severity of the mutation it may not be detected, or a malformed baby might result. The malformation may not interfere with the ability of the baby to live, or it may kill it before it is born.

Mutations are considered to an essential step leading to cancer. Mutations probably cause a small percent of fetal malformations. Ionizing radiations of natural origin are probably the single most important cause of mutations.

TERATOGENESIS

Physical or chemical agents that cause fetal malformations are called teratogens. Teratogens may or may not be mutagens; they can also act in other ways to produce a malformed fetus. We do not know what percent of spontaneous abortions, stillbirths, and fetal abnormalities are due to teratogens. But because of the following considerations we assume they are minor problems.

Probably one of the major causes of fetal abnormalities is disease of the mother. Other recognized causes are heredity, diet, drug or alcohol abuse, smoking, age of the mother, and natural

radiation and x-rays. Very few chemicals are known to be teratogenic for humans.

To cause a malformation, a teratogen must reach the developing embryo during the critical stage of organ development. For the human, this period starts 2 weeks after conception and lasts about 10 to 12 weeks. The kind of malformation that results depends upon what stage of development the embryo is in when it is exposed.

CARCINOGENESIS

Cancer is a much feared and debated subject. There is no dispute about whether chemicals can cause cancers, but experts disagree about how many chemicals may cause cancer in humans. The experts also disagree on the percent of human cancers that are due to exposures to chemicals. Neither do they agree on the mechanism by which chemicals cause cancer. There is debate over whether or not there are safe levels of exposure to chemicals that may cause cancer.

CHEMICALS THAT CAN CAUSE CANCER

Mutagenesis is considered to be a basic step in the development of a cancer. Some fairly simple tests use single-celled organisms to determine whether a chemical could cause mutations. Many chemicals have been shown to be mutagenic in these tests. Regulatory agencies consider these chemicals to be possible causes of cancer in humans. Studies with animals are required to provide more firm evidence of the cancerous properties of these mutagens.

Chemicals that are shown to cause cancer in animals are considered to be probable causes of human cancer. This rule is appled even if the chemical causes cancer in only one species of animal. Further, regulatory agencies do not distinguish between benign tumors and cancers that might be caused by chemicals. Some scientists claim that the distinction between benign and malignant (cancerous) tumors is not clear enough to judge whether a benign tumor will sometime become cancerous.

Few known human cancer agents exist compared to the large number of <u>suspected</u> agents. Very conservative criteria are used by regulatory agencies in classing chemicals as agents of cancer. These criteria place too many chemicals in the list of cancer agents according to many toxicologists.

HUMAN CANCERS THAT ARE DUE TO CHEMICALS

About 15 years ago, a lot of publicity was given to a report that 80 to 90 percent of human cancers were due to environmental chemicals. This erroneous report was the result of a misinterpretation of ideas presented by Dr. John Higginson. His highly regarded thoughts proposed that 80 to 90 percent of cancers are due to environmental "factors". These factors include smoking habits, use of alcohol, exposure to sunlight, diet, natural radiation, and medical treatment. Dr. Higginson estimates that perhaps 2 to 6 percent of cancers are due to occupational exposures to chemicals. The most notable exposure involves asbestos.

HOW DO CHEMICALS CAUSE CANCER?

We know too little about how chemicals cause cancer. Chemicals vary greatly in their interactions with living organisms. A few chemicals appear to be able to cause cancer directly. They are called <u>true carcinogens</u>.

The majority of chemical carcinogens seem to require some sort of chemical change before they can cause cancer. These chemicals are <u>procarcinogens</u>.

Some chemicals cannot cause cancer themselves, or be converted to cancer agents. However, they are able to increase the cancer-causing ability of other chemicals by some means. These chemicals are called <u>cocarcinogens</u>.

The distinction among these three groups of chemicals has only become evident in recent years. Therefore, much of the early data on cancer-causing chemicals does not reveal the group in which a chemical belongs: true carcinogen, procarcinogin, or cocarcinogen.

CHEMICAL CARCINOGENS -- SAFE LEVELS?

"Safe" levels are probably one of the most debated subjects among the experts. Many toxicologists consider that the cancer-causing ability of a chemical is one aspect of its toxicity, and not some special effect that is separate and apart from its toxicity. Thus, they accept the idea of thresholds for cancerous effects just as there are thresholds for toxic effects.

Other scientists maintain that there are no thresholds for cancerous effects of chemicals, and that one molecule of a carcinogen could start a cancer. No experimental methods are available to prove or disprove absolutely either claim.

Despite the controversy about "safe" levels of exposure to carcinogens, no one argues with the fact that there are practical thresholds for carcinogens. The incidence of cancer caused by chemicals is dose-related. For example, the exposure may be so small as to reduce the incidence to one person in a trillion. In that case what practical significance would that exposure have in a world with a population of less than a trillion?

The length of time needed for a cancer to develop after exposure (the induction period) is also dose-related. For example, the exposure may be so small as to increase the induction period to 200 years. In that case, what practical significance would that period have when our average life span is less than 100 years?

LESSON 2
TOXICOLOGY
PART 6 - SOME COMMON MISCONCEPTIONS

A. INTRODUCTION

Many factors govern whether a chemical will produce adverse effects. Because of these factors, the toxicity of chemicals is a complicated subject. As one might expect, a number of wrong ideas have arisen about the toxic actions of chemicals and the science that studies them. These misconceptions will be discussed briefly in this part of the lesson.

B. TERMS YOU NEED TO UNDERSTAND

How well do you know some of the terms that are important in the understanding and use of pesticides? Test your knowledge of them by writing down the definitions for the terms below. To check your answers, refer to the glossary.

1. Sufficient Challenge

2. Bioaccumulation

C. DISCUSSION

SUFFICIENT CHALLENGE

Some people mistakenly think that if a chemical causes harm in any quantity, it will cause harm in every quantity. The reason why this is not so is explained in lesson 2, Part 2. Refer to Part 2 if you have any questions about the importance of the dose-time relationship in determining whether or not a chemical will be toxic.

To illustrate: A lethal dose of caffeine is present in about 100 cups of strong coffee. Thus, anyone who drinks several cups of coffee a day will get a lethal dose of caffeine every month. A lethal dose of alcohol is present in a fifth of hard liquor. Thus, anyone who drinks cocktails regularly will get a lethal dose of alcohol with every thirteenth 2-ounce highball or martini. For people with neither of these vices, there are many, many potentially harmful chemicals that occur naturally in our foods. In the course of a lifetime, we eat or drink many lethal doses of many chemicals. There is no way we can avoid these exposures. However, they do us no harm because we do not receive all these exposures in one dose.

Not only do small amounts of most chemicals do us no harm, very tiny amounts may actually be beneficial. The scientist who first wrote about this revolutionary notion, Dr. Henry Smyth, called the concept "Sufficient Challenge." Dr. Smyth put into writing what toxicologists have noted in their research -- the very smallest doses of foreign chemicals fed to animals often produced healthier, longer-lived

animals than the control animals. The tiny dose stimulated the body's defense mechanisms. In turn, the body became stronger.

The concept of sufficient challenge should not encourage anyone to be careless with chemicals. However, as Dr. Smyth stated, general recognition of this concept "would do much to alleviate the emotional revulsion which the thought of chemicals in daily life so often evokes."

TRANS-SCIENCE

Some people expect science to find answers to all questions that can be asked. Unfortunately, this is not possible. In the words of Dr. Alvin Weinberg, "I propose the term 'trans-scientific' for [some] questions since" although they "can be stated in the language of science, they are unanswerable by science; they transcend science."

For example, one may ask, "will chronic exposure to small amounts of some foreign chemical be harmful to me?" The answer cannot be given with a definite "yes" or "no." The fact that toxicology cannot provide absolute answers to such questions should not be cause for alarm. Toxicologists can judge the possibilities and probabilities of harm resulting from exposure to chemicals. These judgments, combined with suitable margins of safety, have been proven to protect our health.

BIOACCUMULATION

The idea that we store foreign chemicals in our bodies, and accumulate them indefinitely upon every exposure to them is very frightening and totally false.

Our bodies are not inert objects like stones. They function in a state called dynamic equilibrium. This state can be likened to a of marble from which some marbles are constantly being removed while, at the same time, an equal number of marbles are being added. There is no change in the total number of marbles, but the marbles present in the box at any one time may not be the same ones that were present earlier, or that will be present later. So it is with our bodies. Atoms and molecules constantly move in and out of the cells and tissues of our bodies. Although they are constantly moving in and out, the total numbers remain the same (within normal limits).

If a chemical can be stored in our fat, liver, or bones, it will increase only to a level that brings it into equilibrium with the level of exposure. At this point, the amount going into storage equals the amount coming out of storage. (The number of marbles going in equals the number coming out.)

When the exposure level increases, the number of molecules going into storage increases over the number that are coming out of storage. In this case, the level of storage increases until a new equilibrium is reached. When the exposure level decreases, the number of molecules going into storage is less than the number coming out. In this case, the level of storage decreases until a new equilibrium is reached. If exposure terminates, all of the stored chemical is eliminated from the body. The time needed to reach equilibrium and the level of storage at equilibrium are different for each chemical.

Storage is considered to be a defense mechanism of the body. A storage depot serves as a buffer. During periods of increased exposure, the chemical is removed from circulation into the storage depot, where it does no harm. When exposure ceases, the chemical moves out of the depot and is eliminated from the body. The depot can be used for future storage, if necessary. Only when exposure is too high or prolonged with the storage site becomes saturated. Then the amount of circulating chemical becomes greater than the body can tolerate, and harm results.

SELF TEST

AND

ANSWERS

LESSON 2 - PART 1
SELF TEST

1. Toxicology is the science that studies the

   a. medicinal effects of chemicals.
   b. harmful effects of chemicals.
   c. beneficial effects of chemicals.

2. Living organisms can distinguish between natural and synthetic chemicals.

   a. True
   b. False

3. The laws of toxicology apply only to natural chemicals.

   a. True
   b. False

4. Pesticide, as a class, are more toxic than many of the other chemicals we encounter in our daily lives.

   a. True
   b. False

5. The toxicity of a chemical bears no relation to how it is used.

   a. True
   b. False

6. The most important component of chemical hazard is

   a. how it is used and stored.
   b. how it is named.
   c. the warning statement on the label.

LESSON 2 - PART 2
SELF TEST

1. Of the many factors that determine whether a chemical will be toxic, the most important is:

   _____a. age
   _____b. state of health
   _____c. how much exposure and how often
   _____d. individual susceptibility

2. If a chemical is acutely toxic, it will also be chronically toxic:

   _____a. True
   _____b. False

3. The most common routes of exposure for people who work with numerous chemicals are:

   _____a. oral and dermal
   _____b. dermal and inhalation
   _____c. inhalation and oral

4. After handling chemicals, you should always wash your hands before eating or smoking because:

   _____a. clean hands look better than dirty ones
   _____b. we might inhale any dirt that may be on them
   _____c. we might contaminate our food or cigarettes

5. The poorest barrier to the entry of chemicals into the body is offered by:

   _____a. the intestines
   _____b. the lungs
   _____c. the skin

6. Every chemical has ( ) kind s of acute toxicity.

   _____a. two
   _____b. three
   _____c. four
   _____d. six

7. When two chemicals in combination are more harmful than the sum of the individual toxicities, the effect is known as:

   _____a. additive
   _____b. synergism
   _____c. antagonism

LESSON 2 - PART 3
SELF TEST

1. Toxic chemicals cause damage at the point where they touch the body, whereas corrosive chemicals do damage at a site removed from the point of contact:

   a. True
   b. False

2. Chronic toxicity is much easier to study in the laboratory than is acute toxicity:

   a. True
   b. False

3. An oral LD 50 tells us something about how toxic a chemical is when:

   a. inhaled
   b. absorbed by the skin
   c. taken in food or drink

4. The greater the LD 50, the greater the acute toxicity:

   a. True
   b. False

5. A chemical with an oral LD 50 of 20 mg/kg would probably have an average lethal dose for a 100 kg man of:

   a. 20 mg
   b. 200 mg
   c. 2,000 mg
   d. 20,000 mg

6. If a person suffers a mild accidental poisoning, the chances are that he will never fully recover:

   a. True
   b. False

LESSON 2 - PART 4
SELF TEST

1. We know less about chronic, adverse effects of chemicals than we do about acute effects because:

   a. They are not as important as acute effects.
   b. We do not know how to study them.
   c. They are extremely difficult and expensive to perform.

2. People who work with pesticides have less information about the toxicity of the chemicals they work with than do workers in general industry.

   a. True
   b. False

3. The term LD 50 applies to both acute and chronic toxicity:

   a. True
   b. False

4. Thresholds are absolute values determined in animals that can be applied directly to man:

   a. True
   b. False

5. If a no-effect level of a chemical in food is determined to be 700 mg/kg of food (700 ppm), the amount permitted to be in human food would be no more than:

   a. 7 ppm
   b. 1 ppm
   c. 100 ppm
   d. 700 ppm

6. Chronic adverse effects of chemicals are:

   a. dose-related
   b. predictable
   c. both a and b
   d. only a
   e. only b

LESSON 2 - PART 5
SELF TEST

1. The common connection among mutagenesis, teratogenesis, and carcinogenesis is:

   a. Cancer
   b. Chemicals
   c. Mutation

2. Quite a few pesticides are known human carcinogens:

   a. True
   b. False

3. Only a small fraction of human cancers are due to exposure to environmental chemicals:

   a. True
   b. False

4. Few chemicals appear to cause cancer directly:

   a. True
   b. False

5. The existence of thresholds for carcinogens is:

   a. A subject on which all scientists agree
   b. A proven fact
   c. A subject that is much debate

LESSON 2 - PART 6
SELF TEST

1. A chemical that is toxic under some conditions is not necessarily toxic under some other conditions:

   a. True
   b. False

2. Because of sufficient challenge (the theory that trace amounts of foreign chemicals may be beneficial) we do not have to be very careful to protect ourselves when we handle potentially toxic chemicals:

   a. True
   b. False

3. Science is capable of:

   a. answering any question that can be asked of it.
   b. Giving a definite "yes" or "no" to any question asked of it.
   c. answering some questions and making judgments about others.

4. If a chemical is stored in your body, it stays there for the rest of your life.

   a. True
   b. False

This lesson has been based on the book The Dose Makes the Poison by M. Alice Ottoboni, Ph.D. You will expand your knowledge and increase your understanding of this lesson by reading her book.

ANSWERS - LESSON 2

PART 1

1. b
2. b
3. b
4. b
5. a
6. a

PART 2

1. c
2. b
3. b
4. c
5. b
6. b
7. b

PART 3

1. b
2. b
3. c
4. b
5. c
6. b

PART 4

1. c
2. b
3. b
4. b
5. a
6. c

PART 5

1. c
2. b
3. a
4. a
5. c

PART 6

1. a
2. b
3. c
4. b

LESSON 3

THE PESTICIDE LABEL

A. INTRODUCTION

Pesticide labels have been called the most expensive literature printed. The research and development that lead to the wording on a label cost millions of dollars and require years of testing. The combined knowledge of many scientists -- including toxicologists, chemists, pathologists, pharmacologists, and others in industry, universities, and government -- has been used to develop information found on each pesticide label.

B. TERMS YOU NEED TO UNDERSTAND

How well do you know some of the terms that are important in the use of pesticides? Test your knowledge of them by writing down the definitions for the terms below. To check your answers, refer to the glossary.

1. Label

2. Signal Words

3. Trade Name

4. Common Name

5. Chemical Name

6. Volatility

7. Low-Volatile (pesticide)

C. DISCUSSION

Each time you buy a pesticide, you also receive instructions to tell you how to use it. Those instructions are the labeling. What is labeling? What is a label? These words seem alike but they do not mean the same thing.

Labeling is all the information that you receive from the company or its agent about the product. Labeling includes such things as:

- The label on the product
- Brochures,
- Flyers, and
- Other information handed out by the suppliers.

The label is the information printed on or attached to the container of pesticides. This label does many things:

- To the manufacturer, the label is a "license to sell".

- To the State or Federal Government, the label is a way to control the distribution, storage, sale, use, and disposal of the product.

- To the buyer or user, the label is a main source of facts on how to use the product correctly and legally.

- The label is a way to tell users about special safety measures needed.

Some labels are easy to understand. Others are complicated. But all labels will tell you how to use the product correctly. The section below will explain most of the items that must be on a label.

PARTS OF THE LABEL

Brand Name - Trade name

Each company has brand names or trade names for its products. The brand or trade name is the one used in advertisements. The brand name shows up plainly on the front panel of the label. It is the most identifiable name for the product.

Common Names - Chemical Names

Many pesticides have complex chemical names. Some pesticides have been given another name to make them easier to identify. These are called common names. For instance, carbaryl is the common name for 1-naphthyl-N-methylcarbamate (chemical name). The same pesticide may be formulated or distributed by more than one company, and sold under several brand names. The same common or chemical name appearing on all of them.

Type of Formulation

Different types of pesticide formulations (such as liquids, wettable powders, and dusts) require different methods of handling. The label will

tell you what type of formulation the package contains. The same pesticide may be available in more that one formulation.

Ingredient Statement

Every pesticide label must list what is in the product. The amount of each active ingredient is given as a percentage by weight or as pounds per gallon of concentrate. The active ingredient can be listed by either its chemical name or its common name. The inert ingredients need not be named, but the label must show their percent of the contents.

Net Contents

The net contents number tells you how much is in the container. This can be expressed in gallons, quarts, or other units of measure.

Name and Address of Manufacturer

The name and address of the maker or distributor must appear on the label. Anyone can then contact the manufacturer or distributor if they have a question or want more information on the product.

Registration and Establishment Numbers

A registration number must be on every pesticide label. This number shows that the product has been registered with the Federal Government. The number usually appears on the front panel of the label and will be written as "EPA Registration No. 0000". The establishment number tells what factory made the chemical. This number does not have to be on the label, but will be somewhere on each container.

Signal Words and Symbols

To do their job, most pesticides must control the target pest, whether it be insect, plant, animal, etc. By their nature, pesticides are toxic by varying degrees to one or more pests. Therefore, some may also be hazardous to people. You can secure information on the toxicity of a product by reading the signal word and looking at the symbol on the label.

Signal Words

Signal Words	Toxicity	Oral LD 50 Ranges
DANGER	Highly toxic Category I	0-50 mg/kg
WARNING	Moderately toxic Category II	50-500 mg/kg
CAUTION	Low toxicity Category III	500-5000 mg/kg

All products must bear the statement "Keep out of reach of children".

Symbol

Symbols are good ways to catch a person's eye. This is why a skull and crossbones symbol is used on all highly toxic materials along with the signal word DANGER and the word POISON. Pay attention to the symbol on the label. It is there to remind you of the contents.

Public laws require that all pesticide products meeting the criteria of Toxicity Category I shall bear on the front panel the signal word "Danger". In addition, if the product was assigned to Toxicity Category I on the basis of its oral, inhalation or dermal toxicity (as distinct from skin and eye local effects) the word "Poison" shall appear in red on a background of distinctly contrasting color and the skull and crossbones shall appear in immediate proximity to the word "poison".

The Velpar L label is an example of a label that has "DANGER" on it, but is not in Toxicity Category I.

Precautionary Statement

Hazards to Humans (and Domestic Animals)

This section of the label will tell you the ways in which the product may be dangerous to man and animals. It will also indicate other special steps you should take to avoid injury, such as the kind of protective equipment needed.

If the product is highly toxic, this section will inform physicians of the proper treatment for possible injury.

Environmental Hazards

Pesticides are useful tools. However wrong or careless use can cause undesirable effects. To help avoid these effects, the label contains environmental precautions that you should read and follow.

Here are some examples:

- "This product is toxic to bees exposed to direct treatment or to residues on crops".

- "Do not contaminate water when cleaning equipment or when disposing of wastes".

- "Do not apply where runoff is likely to occur".

Labels may also contain broader warnings against harming birds, fish and wildlife.

Physical and Chemical Hazards

This section of the label will tell you of any special fire, explosion, or chemical hazards of the product.

Statement of Practical Treatment

The label will tell you emergency first aid measures. It will also tell you what types of exposure require medical attention.

The pesticide label and safety data sheet are the most important information you can take to the physician when you think someone may have been injured by a pesticide.

Statement of Use Classification

Every pesticide label must show whether the contents are for general use or restricted use.
General use pesticides are very unlikely to harm the applicator or the environment when used as directed on the label.

Restricted use pesticides carry the potential to harm the applicator and the environment even when directed on the label. The label on these

products will say: "Restricted use pesticide for retail sale to and application only by certified applicators or persons under their direct supervision".

The restricted use statement must be at the top of the front panel of the label.

Directions for Use

The instructions on how to use the pesticides are the best way you can find out the right way to apply the product.

The use instructions will tell you --

- the pests for which the product is registered to control (Labels use common names for pests. Knowing the names of the pests will aid in choosing the correct pesticide.)

- The crop, animal, or other item on which the product can be used,

- Whether the product is for general or restricted use,
- In what form the product is to be applied,

- How much to use, where the pesticide should be applied, and when it should be applied.

Misuse Statement

This section of the label will remind you that it is a violation of Federal law to use a product in a manner inconsistent with its labeling. Do not use the product on a site which is not listed on the label. Do not use it at more than the recommended rate.

Re-entry Statement

An area that has been treated with one of the more toxic pesticides may have a set period of time after treatment before allowing re-entry. If required for the product, this section of the pesticide label will tell you how much time must pass before the treated area is safe for entry by a person without protective clothing.

Category of Applicator

If required for the product, this section of the label will limit use to certain categories of commercial applicators.

Storage and Disposal Directions

Every pesticide should be stored and disposed of correctly. This section of the label will tell you how to store and dispose of the product and empty containers. (See the self study guide for safety training of on-the-ground herbicide applicators for further discussion on this topic).

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS

(DANGER)

Poisonous by swallowing or inhalation. Do not breathe spray mist. Do not get in eyes. Avoid contact with skin. Wear a mask or respirator of a type passed by the Mining Enforcement Safety Administration and the National Institute for Occupational Safety & Health for De Pesto protection. For emergency assistance call 000-000-0000

TO PHYSICIAN: De Pesto is a reversible cholinesterase inhibitor. Do not use oximes such as 2-PAM. Give Atropine 2mg. intravenously or subcutaneously. If in eye instill one drop of Homatrophine.

ENVIRONMENTAL HAZARDS

This product is toxic to fish, birds and other wildlife. Birds feeding on treated areas may be killed. Keep out of any body of water. Do not apply where run-off is likely to occur. Do not apply when weather conditions favor drift from areas treated. Do not contaminate water by cleaning of equipment or disposal of wastes. This product is toxic to bees and should not be applied when bees are actively visiting the area.

PHYSICAL OR CHEMICAL HAZARDS

Flammable! Keep away from heat or open flame

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

RE-ENTRY STATEMENT

Do not enter area within five days after application

CATEGORY OF APPLICATOR

For use only by agricultural pest control applicators.

STORAGE AND DISPOSAL

STORAGE - Store in original container. Do not store next to food, water or feed or other articles intended for consumption by humans or animals.

DISPOSAL - Destroy by burying in a safe place.

OR

Contact Local, State or Regional Federal Authorities for local restrictions on disposal.

RESTRICTED USE PESTICIDE

FOR RETAIL SALE TO AND APPLICATION ONLY BY CERTIFIED APPLICATORS OR PERSONS UNDER THEIR DIRECT SUPERVISION

DE PESTO

INSECTICIDE

EMULSIFIABLE CONCENTRATE

ACTIVE INGREDIENT:	
Pestoff *(trisalicylic-2, 5-dichlorocarbamate)*	43.8%
INERT INGREDIENTS:	56.2%
TOTAL:	100.0%

THIS PRODUCT CONTAINS 4.0 LBS OF PESTOFF PER GALLON

SPECIMEN

KEEP OUT OF REACH OF CHILDREN

DANGER — POISON

STATEMENT OF PRACTICAL TREATMENT

IF SWALLOWED - Induce vomiting by giving a tablespoonful of salt in a glass of warm water. Repeat until vomitus is clear. Call a physician immediately.

IF INHALED - Remove to fresh air. Call a physician immediately.

IF IN EYES - Flush eyes with plenty of water for at least 15 minutes. Call a physician immediately.

IF ON SKIN - In case of contact, remove contaminated clothing and immediately wash skin with soap and water.

SEE SIDE PANEL FOR ADDITIONAL PRECAUTIONARY STATEMENTS

A-Z Chemicals, Inc.
Chemcity, Minnesota 55888

EPA EST. NO. 00475
EPA REGISTRATION NO. 1357-42

NET CONTENTS ONE GALLON

DIRECTIONS FOR USE CONTINUED

ALFALFA: Alfalfa Weevil Larvae, Egyptian Alfalfa Weevil Larvae, Pea Aphid, and in New York state for Snout Beetle control. Apply the amount of De Pesto indicated in the chart, when feeding is noticed or when insects appear. Alfalfa Weevil Adult - Apply 1-2 pints per acre when insects appear. Lygus Bugs - Apply 2 pints per acre prior to bloom. Observe the indicated number of days after application before cutting or grazing. Do not apply more than once per season. Apply only to fields planted to pure stands of Alfalfa.

Pints of De Pesto Per Acre	Do Not Cut or Graze Within
½	7 days
1	14 days
2	28 days

RED CLOVER: asdf ?lkj asdf ?lkj asdf ?lkj

SELF TEST

AND

ANSWERS

LESSON 3

SELF TEST

1. When you buy a pesticide, you will receive instructions on how it should be used. These instructions will be found on:

   ____ a. The label attached to the container.
   ____ b. Brochures and flyers put out by the manufacturer.
   ____ c. Printed information handed out by your dealer.
   ____ d. All of the above.

2. The most important things to do before using a pesticide is to -

   ____ a. Check and test all safety equipment
   ____ b. Calibrate the spray equipment
   ____ c. Read the pesticide label
   ____ d. Clean the pesticide application equipment

3. Active ingredients of pesticides may be called by different names:

   ____ a. Common
   ____ b. Chemical
   ____ c. Trade
   ____ d. Both a and b

4. Using Exhibit 1, fill in the following:

   The product name shown on this label is _____.
   The common name for the active ingredient is _____.
   The chemical name is _____.
   The pounds of active ingredients are _____.
   The name and address of the manufacturer are _____.

5. The ingredient statement on a label must contain:

   ____ a. The percent of inert ingredients
   ____ b. The names of the inert ingredients
   ____ c. The names of the active ingredient(s) and their percent.
   ____ d. a and c above

6. The EPA registration number on this label tells you:

   ____ a. The name of the factory that made the chemical
   ____ b. That FDA has registered the product
   ____ c. That EPA has registered the product

7. The EPA establishment number on a product:

   ____ a. The factory that made the product
   ____ b. That EPA has registered the product
   ____ c. That the product can be legally sold

8. Match the following:

A. CAUTION	1. Moderately toxic
B. WARNING	2. Highly toxic
C. DANGER	3. Low order of toxicity

9. Every pesticide label must contain the word(s):
   ____ a. "CAUTION"
   ____ b. "DANGER--POISON"
   ____ c. "KEEP OUT OF REACH OF CHILDREN"
   ____ d. "WARNING"

10. A label may have "DANGER" printed on it, without the skull and crossbones, and have a low order of toxicity.

    ____ a. True
    ____ b. False

11. According to Exhibit 1, DEPESTO has which order of toxicity:

    ____ a. Low
    ____ b. Moderate
    ____ c. High

12. Assume that you or someone you're working with is suspected of having been injured by a pesticide. The first source of information and instructions for first aid should come from:

    ____ a. A county agent
    ____ b. The pesticide label
    ____ c. A reference book on poisons
    ____ d. The local pesticide dealer

13. For everyone's safety and to keep in line with regulations, you should handle pesticides:

    ____ a. As instructed by your salesperson at the time of purchase.
    ____ b. In the same way your friend or co-worker does.
    ____ c. In the same way that has always worked for you.
    ____ d. According to the labeling.

14. A restricted use pesticide can only be legally used by:

    ____ a. A certified applicator, or someone he/she is supervising
    ____ b. A professional pest control operator
    ____ c. Either of the above

15. The most important information you can give a physician when a person is suspected of having been injured by a pesticide is:

    ____ a. How long the person has been exposed
    ____ b. What first aid you have applied
    ____ c. The label, and the safety data sheet of the suspected pesticide.

ANSWERS - LESSON 3

1. d

2. c

3. d

4. Product name is Depesto.
   Common name is Pestoff.
   Chemical name is (trisalicylic-2, 5-dichlorocarbemate). Pounds of Active Ingredients is 4.
   Name and Address of manufacturer is AZ chemicals, Inc. Chemcity, Minnesota 55885.

5. d.

6. c

7. a

8a. 3
b. 1
c. 2

9. c

10. a

11. c

12. b

13. d

14. a

15. c

PESTICIDE FORMULATIONS AND ADJUVANTS

LESSON 4

A. INTRODUCTION

The active ingredients in a pesticide are the chemicals that control the target pest. Pesticides are rarely made up only of active ingredients. Usually a pesticide is diluted in water or a petroleum solvent with other chemicals being added before the product is offered for sale. These other chemicals may include surfactants, wetting agents, spreaders, stickers, extenders, diluents, etc. They usually make the product safer, easier to apply, more convenient to handle, and more accurate to measure. This combination of active and inert (inactive) ingredients is called a pesticide formulation. Some formulations are ready to apply. Others must be further diluted with water or a petroleum solvent by the user before they are applied.

B. TERMS YOU NEED TO KNOW AND UNDERSTAND

How well do you know some of the terms that are important in the use of pecticides? Test your knowledge of them by writing down the definitions for the terms below. To check your answers, refer to the glossary.

1. Formulation

2. Adjuvant

3. Surfactant

4. Solution

5. Suspension

6. Synergism

7. Emulsion

8. Invert emulsion

9. Absorption

10. Adsorption

11. Compatible

C. DISCUSSION

TYPES OF FORMULATION

Pesticides are often sold in several different kinds of formulations. You should choose the formulation that will be best for each use. In making your choice, consider:

- the plant, animal, or area to be treated or protected,
- application equipment available and best suited for the job,
- hazard of drift or runoff,
- safety to applicator, and other humans and pets likely to be exposed,
- habits or growth patterns of the pest,
- costs, and
- type of environment in which the application is to be made.

The most common types of liquid and dry formulations are described in the following sections. The abbreviations are included because the labels and labeling may refer to the formulations in this way.

Liquid Formulations

Emulsifiable Concentrates (EC or E)

An emulsifiable concentrate can be mixed with water to form an emulsion. Diluted EC's usually need a small amount of agitation in the spray tank.

Solutions (S)

Formulations of these pesticides contain the active ingredient and one or more additives. When mixed with water, the pesticide formulation forms a solution that will not settle out or separate. Solutions may be used in about any type of sprayer.

Ultra Low Volume (ULV) Concentrates

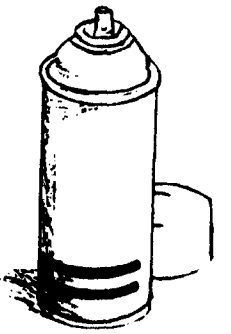
ULV concentrate solutions contain 8 or more pounds of active ingredient per gallon. The solution may be close to 100 percent active ingredient. ULV concentrates are designed to be used as is or to be diluted with only small quantities of specified solvents.

Low Volume (LV) Concentrates

These formulations usually contain less than 2 pounds of active ingredient per gallon. Many of them are solutions in highly refined oils. Generally no further dilution is needed. The label will give you directions for use.

Flowables (F or L)

Some active ingredients can be made only as a solid, or a semi-solid. These ingredients are finely ground and put into a liquid along with other substances that make the mixture form a suspension. This suspension is a flowable solid. Flowables can be mixed with water. They seldom clog spray nozzles. They need only moderate agitation in the spray tank.



Aerosols (A)

Aerosols or "bug bombs" are usually pressurized cans that contain a small amount of pesticide that is driven through a small nozzle under pressure from an inert gas. Aerosols are often used as household pesticides. Aerosols can pose a hazard when transported during hot weather.

Liquified Gas

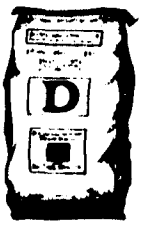
Some fumigants are gases that become liquid when placed under pressure. The pressure in the container may be either high or low,

depending on the product. Some nematicides, insecticides, fungicides, and rodenticides are formulated this way. These formulations are applied by:

- injecting them directly into the soil,
- releasing them under tarps, or
- releasing them into a structure such as a greenhouse.

Some other active ingredients remain liquid in an ordinary container, but turn into a gas as they are applied.

Dry Formulations

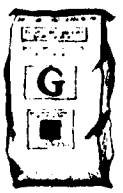


Dust (D)

Most dust formulations are ready to use and contain:

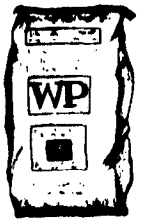
- an active ingredient, plus
- a very fine or powdered, dry, inert substance such as talc, clay, nut hulls, or volcanic ash.

The amount of active ingredient usually ranges from 1 to 10 percent. All the ingredients are ground into fine, uniform particles. Dust always must be used dry. A dust can easily drift into nontarget areas.



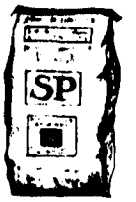
Granules (G)

Granular formulations are made by applying a liquid formulation of the active ingredient to coarse particles (granules) of some porous material. Granules are much larger than dust particles. The pesticide may be adsorbed to the granule, or only coat the outside or both. Granular formulations are safer to apply than EC's or dusts. Granular formulations, like dusts, should always be used dry, not mixed with water.



Wettable Powders (WP or W)

These formulations, are dry, finely ground and look like a dust. But, unlike dusts, WP's are made to mix with water. Most wettable powders are much more concentrated than dusts. Wettable powders form a suspension rather than a true solution when added to water. Continuous agitation is needed in the spray tank to maintain the suspension.



Soluble Powders (SP)

Soluble powders also are dry formulations. But when they are added to water, the SP forms a true solution. Agitation in the spray tank may be needed to get them to fully dissolve. After that, no more agitation is needed.

Baits (B)

A bait is a formulation that attracts pests. Pesticide incorporated in the bait

kills the pest which eats the formulation. Baits are generally used to control rodent and insect pests. The amount of active ingredient in most bait formulations is quite low, usually less than 5 percent.

ADJUVANTS- ADDITIVES

An adjuvant is a substance added to a pesticide formulation, or tank mixture to increase the effectiveness of the active ingredient. Most pesticide formulations contain additives. Some product labels recommend that adjuvants not be used. Caution must be taken; indiscriminatly adding adjuvants may decrease the effectiveness of the pesticide. Some common adjuvants and their effects on pesticide formulations are:

- Anti-foaming agents which reduce the foaming of spray mixtures that may result from vigorous agitation;
- Buffers are used when mixing pesticides of different acidity or alkalinity;
- Drift retardants (thickeners) reduce drift by increasing the droplet size. They can also help reduce foaming;
- Emulsifiers allow petroleum-based pesticides to mix with water to form emulsifiable concentrates (EC's);
- Invert emulsifiers allow water-based pesticides to mix with petroleum carriers to form a mixture containing a water-soluble pesticide dispersed in oil;
- Penetrants help get a pesticide through the outer surface to the inside of a target pest;
- Softeners reduce phytotoxicity of a pesticide on a plant;
- Stickers help keep pesticides on the treated area;
- Spreaders help form uniformly, coated layers over the treated area, and;
- Surfactants increase the emulsifying, dispersing, spreading and wetting properties of a pesticide product. Enhances the combining of liquids with different properties, such as water and oil.
- Wetting agents reduce the surface tension of pesticide mixtures to increase surface spread. They are also used in mixing wettable powders with water to increase their adherance to a treated surface.

An adjuvant usually contains more than one of the above additives.

COMPATIBILITY

Mix two or more pesticides together only if they are compatible, one does not affect the properties of the other. Some different pesticides are formulated together by the manufacturer. Also, some pesticide labels list other pesticides with which they are compatible. Other labels may state that you should not mix the product with certain pesticides.

It is very important not to indiscriminately mix pesticides. The material should always be mixed for specific-use reasons, and only then when compatibility has been determined.

It is also important to check for compatibility of the pesticide with the spray tank and application components. A pesticide may react with incompatible application equipment, causing excessive corrosion, dangerous gases, etc.

SELF TEST

AND

ANSWERS

LESSON 4

SELF TEST

1. Which of these pesticide formulations would form a true solution when mixed with water:

   ____ a. Wettable Powders
   ____ b. Emulsifiable concentrates
   ____ c. Solutions

2. When two or more pesticides can be mixed together and one does not affect the properties of the other, they are said to be:

   ____ a. Synergistic
   ____ b. Complimentary
   ____ c. Phytotoxic
   ____ d. Compatible

3. Match the following:

   ____ a. Suspension
   ____ b. Solution
   ____ c. Emulsion
   ____ d. Invert emulsion

   1. The ingredients will not settle out.
   2. Suspension of water in oil.
   3. Suspension of oil in water
   4. Particles mixed (dispersed) in a liquid.

4. Dusts drift less than granular formulations:

   ____ a. True
   ____ b. False

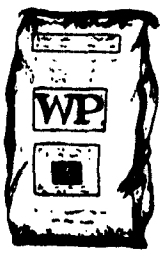
5. Adjuvants are sometimes added to pesticides to:

   ____ a. Reduce foaming
   ____ b. Reduce drift
   ____ c. Aid in penetration
   ____ d. All of these

6. Liquefied gases are used as:

   ____ a. Fumigants
   ____ b. Sprays
   ____ c. Flowables

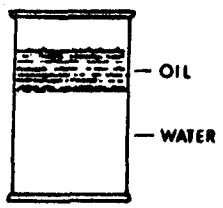
7. Which of these must be agitated as applied?



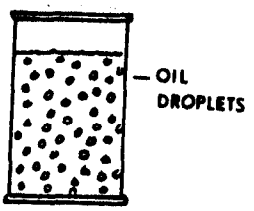
____ a.

____ b.

8. Which picture shows an emulsion?



____ a.



____ b.

9. Match the following:

____ a. Baits
____ b. Dusts
____ c. Granules
____ d. Soluble powders
____ e. Wettable powders
____ f. Surfactant
____ g. Synergistic

1. Dry formulation that dissolves in water.
2. Forms a suspension in water
3. Attracts pests.
4. Coarse particles.
5. Fine powders applied dry.
6. When two pesticides are mixed together their activity is greater than the sum of the two.
7. Aids in mixing oil and water.

10. Most dust and granular formulations are to be mixed with water prior to application.

____ a. True
____ b. False

ANSWERS - LESSON 4

1. c

2. d

3a. 4
b. 1
c. 3
d. 2

4. b

5. d

6. a

7. a

8. b

9a. 3
b. 5
c. 4
d. 1
e. 2
f. 7
g. 6

10. b

LESSON 5

PESTICIDE LAWS, REGULATIONS, AND FOREST SERVICE POLICY

A. INTRODUCTION

Without pesticides, we would not have the food, fiber, and the quality of life we have come to expect. Because pesticides can be dangerous if used improperly, Congress has passed laws affecting pesticide use. These laws try to balance the need for pesticides against the need to protect people and the environment from their misuse.

You, as a Forest Service employee, need to be familiar with these laws and regulations, as well as Forest Service policy regarding pesticide use.

B. TERMS YOU NEED TO UNDERSTAND

How well do you know some of the terms that are important in the use of pesticides? Test your knowledge of them by writing down the definitions for the terms below. To check your answers, refer to the glossary.

1. Restricted-use Pesticide

2. Certified applicator

3. Residue

4. Tolerance

5. Suspended

6. Cancelled

C. DISCUSSION

The FEDERAL INSECTICIDE FUNGICIDE, AND RODENTICIDE ACT (FIFRA), as amended is the law, that regulates the registration, manufacture, transportation, and use of pesticides. FIFRA was substantially amended in 1974 and 1978. The law affects the user in many ways. Most importantly, FIFRA provides that --

- all pesticides must be used only as directed on the label.
- all pesticide uses must be classified as "restricted" or "general".
- persons who buy or use restricted-use pesticides must be certified as competent pesticide applicators or must be directly supervised by a certified applicator.
- persons who do not obey the law will be subject to penalties (fines and jail terms).

The Environmental Protection Agency (EPA) administers FIFRA and by regulation has set minimum standards of competence for users of restricted use pesticides. The Forest Service, in certain categories, and the States have developed their own plans for certification of competency that meets EPA's standards. A person who wishes to become certified by a Federal or State agency should know the information in the following sections.

Use Inconsistent with the Label

A pesticide may not be used in any manner which is not permitted by the labeling. You must use the pesticide only on the plants, animals, or sites specified in the directions for use. You may not use higher dosages, higher concentrations, or more frequent applications than specified. You must follow directions for use, safety, mixing, diluting, storage, and disposal -- as well as restrictions on re-entry and days to harvest, slaughter, and grazing.

The law <u>does</u> allow you to --

- apply a pesticide against any target pest not listed on the labeling <u>if</u> the application is to a crop, animal, or site that is listed.
- use any equipment or method of application that is not prohibited by the labeling.
- mix a pesticide or pesticides with a fertilizer if the mixture is not prohibited by the labeling.
- mix two or more compatable pesticides if all the dosages are at or below the recommended rate.

Classification of Pesticide Uses

EPA directs that pesticides will be classified as "restricted" or "general". Many times, all the uses of a particular formulation are classified as restricted or all of them are classified as general. Sometimes, however, certain uses of a formulation are restricted and other uses of the same product are not. For example, TORDON 101 is restricted; TORDON 101R is not restricted. In these cases the directions for use for the two classifications must be clearly separate from one another.

A pesticide (or some of its uses) will be classified as "general use" if it is not likely to harm humans or the environment when used as directed on the label.

A pesticide (or some of its uses) will be classified as "restricted use" if it could cause human injury or environmental damage if not applied by competent persons (certified applicators) who have demonstrated the ability through testing to use these pesticides safely and effectively.

Classification of pesticides and pesticide uses may be based on --

- the potential for injury of humans,
- the type of formulation,
- the way the pesticide is used,
- the place in which the pesticide is used, and
- the potential for harm in the environment.

When a pesticide is restricted, the label will read "Restricted Use Pesticide" on a prominent part of the front panel. When a pesticide is classified for general use, the words "General Classification" will appear immediately below the heading "Directions for Use".

NOTE: Although EPA has classified many pesticide products and uses, a few pesticides have not yet been classified. In these instances, you should pay close attention to the signal words and human and environmental hazard statements on each product.

Certification of Applicators

Persons who are not certified pesticide applicators may not purchase or use restricted use pesticides unless they are directly supervised by a certified applicator.

Certification requires training and testing for competency in the safe and effective handling and use of these pesticides.

The State or Federal agency may conduct the training and tests for certification. The State may impose stricter standards than those required by FIFRA. EPA requires each State and Federal agencies with certification plan to maintain a program to assure that certified applicators have current certification. This certification is not like a doctor's or plumber's license that is good for the holder's entire career. A certified applicator must be recertified at set periods. Check with your State or Agency to determine the requirements you need to meet.

Many adjoining States have developed agreements to allow certification in one State to be accepted in the nearby States or throughout a region. The Forest Service has developed reciprocal agreements with many States.

Certified pesticide applicators fall into two groups -- private applicators and commercial applicators. The differences are discussed in the following sections.

PRIVATE APPLICATORS

Private applicators are persons who use or supervise the use of restricted-use pesticides in producing an agricultural commodity on property owned or rented by themselves or their employer, or on the property of another person with whom they trade services. Examples of private applicators are farmers, ranchers, floriculturists, and orchardists. Private applicators are trained or tested in the safe use and handling of pesticides and pest control practices associated with agricultural operations.

COMMERCIAL APPLICATORS

Commercial applicators are persons who use restricted-use pesticides for hire on property other than their own, and government workers (For example, Forest Service employees) who apply pesticides on their jobs. Commercial applicators are trained and tested in the general areas of safe use and handling of pesticides. They then receive training and testing in one or more specific uses, including --

- agricultural pest control (plant or animal)
- forest pest control
- ornamental and turf pest control
- right-of-way pest control
- seed treatment
- aquatic pest control

- industrial, institutional, structural, and health-related pest control,
- regulatory pest control, and
- demonstration and research pest control.

Several States have different or additional categories for commercial applicators. These categories include, for example, aerial application or wood preservation.

It is illegal to apply a restricted-use pesticide in a category in which you are not certified.

PENALTIES

If you violate the law or regulations enacted under FIFRA, you are subject to civil penalties. The fine can be as much as $5,000 for each offense ($1,000 for private applicators). Some violations of the law may also subject you to criminal penalties. These can be as much as $25,000 or 1 year in prison, or both, for commercial applicators. Therefore, to use a pesticide in a manner inconsistent with its labeling is a violation of federal law, state law, and Forest Service policy.

REGISTRATION

Every pesticide that is bought, sold, or used in the United States must, by law, be registered by EPA. EPA approves not only the product itself, but also each separate use for which the product is intended, as well as the product label. You are responsible for applying only those pesticides that are registered.

You may encounter three major types of registration --

- Federal registration
- special local-needs registration
- emergency exemptions from registration.

Federal EPA Registrations are the most familiar. Most pesticide uses are registered this way. Look for the official EPA registration number (which must appear on the label) to be sure you are buying an approved product.

Special local-needs registration (known as SLN or 24(c) registrations) are becoming more common. They allow a State, under some conditions, to register additional uses for a Federally-registered pesticide. These registrations often include additional application sites or pests, as well as alternate control techniques beyond those listed on the Federaly-registered label.

The manufacturer must provide supplemental labeling for each 24(c) registration. Users must have a copy of the 24(c) label in their possession in order to legally apply the pesticide for the purpose shown on that label. These registrations are legal only in the State or local area specified in the labeling.

Emergency exemptions from registration are used when an emergency pest situation arises for which no pesticide is registered. If both Federal and 24(c) registrations would take too long to issue, an emergency registration can be used, known as "Section 18 exemptions". Strict controls and record keeping are required for all these emergency uses. The agency that has granted the emergency exemption will supply you with the necessary rates, safety precautions, and other vital information.

RESIDUES AND TOLERANCES

The pesticide that remains in or on food or feed is called a residue. Residues that remain in food or feed at harvest or slaughter are carefully monitored to avoid hazards to people and domestic animals that will eat these products.

EPA sets residue tolerances in parts per million (ppm) for all crop and animal products intended for food or feed. A tolerance is the maximum

amount of pesticide residue that may remain on or in treated crops and animals that are to be sold for food or feed. These tolerances are determined by extensive testing. To ensure safety, the levels usually are set at least 100 times lower than the amount known to be harzardous. If the residue exceeds the tolerence, the food or feed may not be marketed or sold.

The Food and Drug Administration (FDA) monitors food and feed for tolerance violations. FDA sets tolerances for residues resulting from pesticides applied to food or feed after harvest. This agency may condemn and seize any products exceeding the tolerances and may prosecute violators.

The Meat Inspection Division of the U.S. Department of Agriculture (USDA) monitors pesticide tolerances in animals and animal products.

The 1958 Food Additives Amendment to the Food, Drug and Cosmetic Act includes a part called the Delaney Clause. This clause requires that chemicals used as food additives be considered as human carcinogens if they produce cancer in any animal species, at any level of exposure. It must be stressed that the Delaney Clause applies only to food additives. During these past 25 years, it has never been extended to any of the many other chemicals in our environment primarily because of objections from the scientific community. With few exceptions, toxicologists reject the concept of the Delaney Clause because it excludes the exercise of scientific judgment in the evaluation of research data.

OTHER REGULATIONS

Transportation

Shipment of pesticides and other dangerous substances across State lines is regulated by the U.S. Department of Transportation (DOT). DOT issues the rules for hauling these materials.

Anyone who ships pesticides between States must know that --

- The pesticides must be in their original packages. Each package must meet DOT standards.
- The vehicle must have a correct sign.
- Manufacturers must put the correct warning signs on each package.
- The pesticides may not be shipped in the same vehicle with food products.
- DOT must be contacted immediately if the vehicle is involved in an accident:

  a) if someone is killed
  b) if someone is injured badly enough to go to a hospital, or
  c) if damage is more than $50,000.

- DOT must be contacted if there is a spill during shipment.

State and local laws may require additional precautions for the transport of pesticide products.

Aerial Application

Application of pesticides from airplanes is regulated by the Federal Aviation Administration (FAA) and may also be regulated by your State. FAA judges both the flying ability of pilots and the safety of the aircraft. FAA rules say that an aerial applicator may not apply any pesticide except as the label directs.

Forest Service Policy

In addition to the laws and regulations that you or a pesticide applicator have to abide by, there is Forest Service policy that must be followed. The policy is contained in Forest Service Manual 2150 (FSM 2150) Pesticide-Use Management and Coordination. You should now review the section of the Forest Service Manual.

SELF TEST

AND

ANSWERS

LESSON 5

SELF TEST

1. Match the following:

____ a. Residue	1. Can use or supervise the use of restricted-use pesticides
____ b. Cancelled pesticide	2. Pesticide left on crop
____ c. Certified applicator	3. No longer legal to use
____ d. Suspended pesticide	4. No longer registered for use

2. All pesticides must be classified and labeled by the manufacturer for --

____ a. general use
____ b. restricted use
____ c. either

3. Applicators who violate FIFRA may be subject to --

____ a. fines
____ b. jail terms
____ c. both a and b

4. Match the following:

____ a. DOT	1. The amount of pesticide residue allowed on farm products and considered safe.
____ b. EPA	2. Sets residue tolerances
____ c. 24(c)	3. Special local-needs registrations
____ d. tolerance	4. Used when an emergency pest situation arises for which no pesticide is registered.
____ e. USDA	5. Monitors food and feed for pesticide tolerance violations.
____ f. FDA	6. Monitors pesticide tolerances in animals and animal products
____ g. Emergency exemption from registration	7. Regulates shipment of pesticides
____ h. FAA	8. Regulates aerial application

5. It is Forest Service policy that pesticides be used as directed on the label.

____ a. True
____ b. False

6. Training and testing for certification may be conducted by --

____ a. State agencies
____ b. Federal agencies
____ c. Both of these

7. USDA Forest Service employees who apply restricted-use pesticides as part of their job are considered --

____ a. private applicators
____ b. commercial applicators
____ c. noncommercial applicators

8. Forest Service policy on the use of pesticides is in Forest Service Manual --

_____ a. 3450
_____ b. 1950
_____ c. 2150

9. A record of the application of restricted use pesticides shall be maintained for --

_____ a. one year
_____ b. two years
_____ c. three years

10. The direct applicaiton of a pesticide to water is to be approved by --

_____ a. Regional Forester
_____ b. Forest Supervisor
_____ c. Forest Pesticide coordinator

11. When a pesticide treated area is posted the sign should indicate --

_____ a. the name and address of the manufacturer
_____ b. the name of the pesticide only
_____ c. the name of the pesticide, date of application, and who to contact for additional information.

ANSWERS - LESSON 5

1a. 2
b. 4
c. 1
d. 3

2. c

3. c

4a. 7
b. 2
c. 3
d. 1
e. 6
f. 5
g. 4
h. 8

5. a

6. c

7. b

8. c

9. b

10. a

11. c

LESSON 6

USING PESTICIDES SAFELY

A. INTRODUCTION

There are many reasons for using pesticides safely, but the primary ones are to protect yourself and other people from injury, and to avoid harming the environment.

Most pesticide accidents result from careless practices or lack of knowledge about handling and applying pesticides safely.

B. TERMS YOU NEED TO UNDERSTAND

How well do you know some of the terms that are important in the use of pesticides? Test your knowledge of them by writing down the definitions for the terms below. To check your answers, refer to the glossary.

1. Penetration

2. Ingested

3. Contaminate

4. Organophosphates

5. Carbamates

6. Organochlorines

C. DISCUSSION

Protecting People:

HOW PESTICIDES CAN HARM US

Pesticides can cause injury. They are toxic, especially the insecticides, and rodenticides. Manufacturers find out how toxic a pesticide is by testing it on animals. The product's hazard -- the danger that it will injure someone -- depends on the toxicity of the active ingredient plus the degree of exposure to the product during use.

Most pesticides can cause injury if misused. However every registered pesticide can be used safely with proper care. Children under 10 are the victims of at least half of the accidental pesticide related deaths in this country. If pesticides were always stored and used correctly, children and adults should never be injured.

Many pesticides can enter the body through the skin. You may get more into your body this way than you would by accidentally swallowing or inhaling while working.

You can help prevent accidents with pesticides by using and storing pesticides away from children and other untrained persons. Always take care to follow directions when using a pesticide.

Products for restricted use need special care. They should be handled only by certified applicators. The label is your guide.

SYMPTOMS OF PESTICIDE POISONING

You should know what kind of sickness can be caused by the pesticides. You also should know the conditions under which each pesticide may make you sick.

Look for two kinds of clues to pesticide illness. Some clues are feelings that only the person who has been injured can notice -- such as nausea or headache. These feelings are signs that are as important as any visible clue. You should know what your own feelings might mean and what signs to look for in your co-workers and others who may have been exposed.

All pesticides in the same chemical group cause the same kind of illness. The effects may be mild or severe, depending on the pesticide and the amount absorbed. However, the pattern of illness caused by one type of pesticide is generally consistent. Of course, every one who has some of these signs and symptoms has not always been injured by a pesticide. Other kinds of sickness may cause similar signs and symptoms. Headache and a feeling of being unwell, for example, may signal the start of many kinds of illness. The pattern of symptoms will make it possible to tell one kind of illness from another.

Get medical advice quickly if you or any of your fellow workers have unusual or unexplained symptoms. If you suspect a person has signs or symptoms of a pesticide illness, do not leave that person alone. Do not let yourself or anyone else get dangerously sick before going to a physician. Take the container (or the label) of the pesticide to the physician along with the safety data sheet if available.

SYNTHETIC ORGANIC PESTICIDES

Organophosphates

These pesticides injure the nervous system. The signs and symptoms go through stages. They usually occur in this order --

Mild Symptoms

- fatigue
- headache
- dizziness
- blurred vision
- too much sweating and salivation

- nausea and vomiting
- stomach cramps or diarrhea

Moderate Symptoms

- unable to walk
- weakness
- chest discomfort
- muscle twitches
- pupil of the eye becomes smaller
- earlier symptoms that become more severe

Severe Symptoms

- unconsciousness
- pupil of the eye becomes very small
- muscle twitches
- secretions of mouth and nose
- breathing difficulty
- death, if not treated

Illness may be delayed for a few hours. However, if the signs or symptoms start more than 12 hours after you were exposed to the pesticide, you probably have some other illness. Check with your physician to be sure.

Carbamates

The only carbamates likely to make you ill on the job act almost like the organo- phosphates. They produce the same signs and symptoms. However, the injury they cause can be corrected more easily by a physician. For this reason, most carbamates are safer than organophosphates. The label will warn you of the danger.

Organochlorines

Not many organochlorines (chlorinated hydrocarbons) have injured the user.

Early signs and symptoms of poisoning include --

- headache
- nausea
- vomiting
- general discomfort, and
- dizziness

With more severe illnesses, convulsions follow. They may even appear without the warning symptoms. A coma may follow the convulsions. The person also may be unusually excited or irritable.

Nitrophenols and Pentachlorophenol

The signs and symptoms of skin exposure include --

- redness
- burning, and
- blisters

Other signs and symptoms of poisoning include -

- headache
- nausea
- stomach ache
- restlessness
- hot feeling
- flushed skin
- sweating
- deep and fast breathing
- fast heart beat
- fever,
- ashen color
- collapse, and
- coma

Severe poisoning usually runs a rapid course. One usually dies or is almost well within 24 to 48 hours.

Fumigants and Solvents

Too much exposure to these compounds may make a person seem drunk. The signs and symptoms are --

- poor coordination
- slurring words
- confusion, and
- sleepiness

Repeated exposure to the fumigant, methyl bromide, has caused permanent internal injury without early signs or symptoms of poisoning. You can absorb a fatal dose of it before symptoms appear.

INORGANIC PESTICIDES

Large, single doses of most inorganic pesticides that are taken in either by mouth or through the skin cause vomiting and stomach pain. The signs and symptoms depend on the mineral from which the pesticide is made.

PLANT-DERIVED PESTICIDES

Some plant-derived pesticides are very toxic. Technical (undiluted) pyrethrum may cause allergic reactions. Some rotenone dusts irritate the respiratory tract. Nicotine is a very fast-acting, toxic substance. Some other plant-derived pesticides are strychnine, rotenone, and red squill.

FIRST AID PROCEDURES

Read the directions in the "Statement of Practical Treatment" on each label. These instructions can save your life and the lives of fellow employees.

If you get a pesticide on your skin, remove the pesticide as quickly as possible. Remove all contaminated clothing. Prompt washing may prevent sickness even when the spill is very large. Don't forget your hair and fingernails. Water-wettable powders or suspensions are easy to remove with plain water. So are most emulsifiable concentrates and emulsions. Solutions of pesticides in petroleum oil or other solvents are harder to remove without soap or a detergent. Detergents work better than soap.

If you inhale a pesticide, get to fresh air immediately.

If you splash a pesticide into your mouth or swallow it --

- Rinse your mouth with plenty of water
- Go (or be taken) to a physician, especially if you swallowed the pesticide.
- It is sometimes dangerous to cause vomiting; follow label directions.

If a pesticide is splashed into the eyes, wash it out immediately with an eyewash bottle for about 10 to 15 minutes. (See the application label and safety data sheet for more information.)

PROTECTING YOUR BODY

Pesticides can enter the body in many ways. The main ones are --

- getting the pesticide on your skin,
- inhaling it, and
- swallowing it.

To prevent this contact, you must wear the recommended protective clothing and equipment. The pesticide label will tell you the kind of protection you need.

Remember to bathe when you finish working with pesticides or pesticide-contaminated equipment. Any time you spill a pesticide on yourself, wash immediately.

PROTECTIVE CLOTHING

Body Covering

Any time you handle pesticides, you should wear at least --

- a long-sleeved shirt and long-legged trousers, or
- a long-sleeved coverall type garment.

This clothing should be made of closely woven fabric. When handling very toxic materials, you also should wear a liquid-proof raincoat or apron. Wear trousers outside of the boots to keep pesticides from getting inside.

Gloves

When you handle highly toxic pesticides, wear liquid-proof neoprene gloves. Always read the label for specific instructions. However, be aware that some fumigants are readily absorbed by neoprene. The label should tell you when and what kinds of gloves to use. They should be long enough to protect the wrist. Gloves should not be lined with a fabric. Sleeves should be outside of the gloves to keep pesticides from running down the sleeves and into the gloves.

Hats

Wear something to protect your head. Headgear should not have a cloth or leather sweatband. These sweatbands are difficult to clean if chemicals get on them. Plastic hard-hats with plastic sweatbands are good.

Boots

For highly toxic materials, wear unlined neoprene boots. However, some fumigants are readily absorbed by neoprene boots. Follow the label instructions.

Goggles or Face Shield

Wear goggles or a face shield when the label recommends that you do so, or if there is a chance of getting pesticides in your eyes. Your eyes will absorb some pesticides. Follow the label instructions.

Care of Clothing

Wear clean clothing daily. If your clothes get wet with spray, change them right away. If they get wet with highly toxic pesticides, destroy them. They are difficult to get clean by normal methods. Do not store or wash contaminated clothing with the family laundry. Wash hats, gloves, and boots daily, inside and out. Hang them to dry. Test gloves for leaks by filling them with water and gently squeezing.

Wash your goggles and face shields at least once a day. Elastic fabric headbands often absorb pesticides and are difficult to clean.

RESPIRATORY PROTECTIVE DEVICES

The respiratory tract -- the lungs and other parts of the breathing system -- is much more absorbent than the skin. You must wear an approved respirator when the label directs you to do so.

Cartridge Respirator

Chemical Cartridge Respirator

You should wear this kind of respirator when you are exposed to an intermittent concentration of highly toxic pesticides, or as recommended by the label. The inhaled air comes through both a filter pad and a cartridge made to absorb pesticide vapors. Most harmful vapors, gases, and particles are removed. These half-face masks cover the mouth and nose. To cover the eyes also, use a mask that is combined with goggles or wear separate goggles.

Canister Respirator

Chemical Canister Respirator Gas Mask

You should wear this kind of respirator when you are exposed to a continous concentration of highly toxic pesticides, or as the label directs.

The canister has longer-lasting absorbing material and filters than does a cartridge respirator. Gas masks usually protect the face better than cartridge types of masks. Neither kind will protect you during fumigation or when the oxygen supply is low.

Supplied Air Respirator

Supplied-Air Respirator

You may use this kind of respirator when mixing or applying highly toxic pesticides --

- when the oxygen supply is low,
- when you are exposed in enclosed areas, as in fumigation, or
- when the label directs the use of this equipment.

Clean air is pumped through a hose to the face mask.

Self-contained Breathing Apparatus

Self-Contained Breathing Apparatus

You should wear this kind of respirator under the same conditions as the supplied air respirator. It does about the same thing. The differences is that you carry cyclinders of air or oxygen with you, usually on your back. This lets you move more freely and over a wider area than you can with a supplied air respirator.

Selection and Maintenance

Specific types of cartridges and canisters protect against specific gasses and vapors. Be sure you choose one made for the pesticide you are using. Use only those approved by the National Institute for Occupational Safety and Health (NIOSH), or the Mining Enforcement and Safety Adminisration (MESA).

The respirator must fit the face well. Long sideburns, a beard, or glasses may prevent a good seal. Read the manufacturer's instructions on the use and care of any respirator and its parts before you use it.

When applying pesticides, change filters, cartridges, and canisters if you have trouble breathing, or if you smell pesticides. Remove and discard filters,

cartridges and canisters after use. Then wash the face piece with detergent and water, rinse it, and dry it with a clean cloth. Store it in a clean, dry place away from pesticides.

The useful life of a cartridge or canister depends on the amount of absorbent materials, the concentration of contaminants in the air, the breathing rate of the wearer, and the temperature and humidity. Follow the manufacturers recommendation.

If you have trouble breathing while wearing a respiratory device, see your physician to find out whether you have a respiratory problem.

PROTECTING THE ENVIRONMENT

The environment is our surroundings and its many forms of life. Water, air, soil, plants, and wildlife are important parts of our environment. Because pesticides can be pollutants, you must use them correctly to prevent harm to the environment. You should be aware of how pesticide contamination can affect our natural resources. By knowing and following good application practices, the applicator and the environment can be protected.

How Pesticides Harm the Environment

Using pesticides in a way other than as directed on the label can injure plants and animals, leave illegal residues, and damage the environment in many other ways. Pesticides can cause harm if not chosen and used with care. Here are some ways damage can occur.

Direct Kill of NonTarget Organisms

Do not let a pesticide contact anything except the target area. Drift from herbicides can kill nearby crops and landscape plants. You may kill bees and other pollinators with insecticides if you treat a crop while they are working in a field. Or you could kill parasites and predators that help control harmful insects.

Runoff from sprayed fields, especially those treated with insecticides, can kill fish in a nearby stream or pond. Life in streams can be harmed by careless tank filling, draining and improper container disposal.

In addition to harming the environment, these misuses can result in lawsuits, fines, and loss of certification.

If more than one pesticide will control your target pest, choose the one that is the least hazardous to the environment and most useful for your situation.

Persistence

Not all pesticides act the same after you apply them. Most are in one of these two groups:

Pesticides that break down quickly, remain on the target or in the environment only a short time before being changed into harmless products.

Pesticides that break down slowly may stay in the environment without change for a long time. These are called persistent pesticides. Most of them are not broken down easily by micro-organisms, and are only slightly soluble in water.

Some persistent herbicides can injure future crops planted during the next year. However these pesticides seem to be of little hazard to the environment beyond the treated soil.

Pesticide Movement in the Environment

Pesticides become a problem when they move off target. Problems may arise when a pesticide --

- drifts out of the target area as a mist or dust,
- moves onto the soil through runoff or erosion,
- leaches through the soil,
- is carried off as residues in crops and livestock, or
- evaporates and moves with air currents.

Soil and Pesticides

Persistent pesticides may limit future planting. You can plant only crops which the pesticide will not kill or contaminate.

Even pesticides directed at plants or animals can move to the soil. They may be washed or brushed off. They may be worked into the soil with dead plant parts.

Air and Pesticides

Mists and fine sprays should be avoided as they may drift onto nontarget areas.

Water and Pesticides

Water can be polluted if you use the wrong pesticide or apply it carelessly, resulting in possible damage to fish and aquatic life.

Pesticides also can reach water directly as a result of --

- drifts,
- spills,
- application to waterways (ditches and streams), and
- incorrect disposal methods.

Pesticides also may reach water indirectly. This happens because of erosion, runoff, and leaching.

Benefits of Careful Use

Pesticides can help the environment when used correctly. Most importantly, they can help produce better quality and higher yields of food, fiber, and timber.

Weigh carefully the advantages and disadvantages of each pesticide use. Choose the pesticide that will do the least damage while giving good control. Plan each part of the job carefully from beginning to end.

SAFE-USE PRECAUTIONS

Read, study, and complete the Forest Service Self Study Guide for Safety Training of on-the-ground Herbicide Applicators.

Read the sections on --

- Labelling and Registration
- Mixing and Applying -- Transportation
- Storage and Spills

SELF TEST

AND

ANSWERS

LESSON 6

SELF TEST

1. A pesticide applicator has a chance of getting more of most pesticides into his/her body through-

   ____ a. Skin
   ____ b. Mouth
   ____ c. Nose

2. Restricted-use pesticides require --

   ____ a. General applicators
   ____ b. Applicators who have 10 hours of pesticide training.
   ____ c. Certified applicators

3. If someone is taken to a physician because of possible injury by a pesticide, the pesticide label should accompany her/him.

   ____ a. true
   ____ b. false
   ____ c. doesn't matter

4. If you spill a concentrated pesticide on your skin, you should wash the exposed area with soap and water --

   ____ a. within 1 hour after you were exposed
   ____ b. as soon as you complete the application
   ____ c. immediately
   ____ d. at your normal bathing time

5. Select the following signs and symptoms you would expect to be associated with organophosphate illness --

   ____ a. blurred vision
   ____ b. constriction of the pupil in the eye
   ____ c. blisters
   ____ d. secretions from mouth and nose
   ____ e. flushed skin
   ____ f. muscle twitches

6. The signs and symptoms of most _____ are similar to those of organophosphates, but the injury can be corrected more easily by a physician.

____ a. organochlorines
____ b. fumigants
____ c. Pentachlorophenols
____ d. carbamates

7. The best headgear to wear when applying pesticides is --

____ a. Redman cap
____ b. Hard hat
____ c. Cotton cap
____ d. Summer straw hat

8. Which of these materials would be good outerwear for pesticide work, not involving concentrated, highly toxic, pesticides --

____ a. Knit shirt
____ b. Denim pants
____ c. Wool shirt
____ d. Cotton work clothes

9. For most highly toxic pesticides, gloves should be made from --

____ a. neoprene rubber with cotton lining
____ b. cotton
____ c. neoprene rubber without lining
____ d. any of the above

10. To prevent a pesticide from getting into an applicator's gloves and boots, shirt sleeves and trousers should be worn --

____ a. outside each
____ b. inside each
____ c. either way

11. The cartridge or canister on pesticide respirators should be changed as often as the manufacturer recommends, or when the applicator smells the chemical.

____ a. True
____ b. False

12. When applying a pesticide in an area where oxygen is low or where fumigants are used, which of these devices can best protect the wearer --

Cartridge Respirator

Supplied Air Respirator

Canister Respirator

____ a. ____ b. ____ c.

13. The respirator you use should be approved for that pesticide by --

____ a. MESA
____ b. NIOSH
____ c. either or both of these agencies.

14. Respirators should be fitted so that --

____ a. fresh air leaks in around the mask so the face shield will not fog up.
____ b. a finger can fit between the face and the edge of the mask to indicate it is not too tight.
____ c. there is a tight seal between the mask and the face.

15. If you have any cuts and skin abrasions, protect them during application, or do not apply pesticides.

____ a. true
____ b. false
____ c. should be of no concern

16. Pesticides should not be transported inside --

____ a. open truck beds or open trailers
____ b. passenger vehicles
____ c. either a or b

17. If an employee spills a large amount of a pesticide on himself, you should --

____ a. Immediately rush the person to a physician.
____ b. Immediately remove the contaminated clothing and wash off the pesticide, begin flushing out the eyes, take the person to the physician.
____ c. Not be concerned.

18. If the sump inside a pesticide storage building contains a liquid, you should --

____ a. not be concerned for that is what it was designed to hold.
____ b. wait until it has evaporated out, then check for leaks.
____ c. Remove the liquid and treat it as a pesticide, then check the sump for possible leaks.

19. An empty pesticide container that has held a liquid shall be --

____ a. rinsed three times.
____ b. rinsed two times.
____ c. rinsed one time.

20. After exposure to an organophosate pesticide, which affects the nervous system, you would expect signs and symptoms to appear within--

____ a. 12 hours or less
____ b. 13 to 24 hours
____ c. 25 to 30 hours
____ d. 31 to 36 hours

21. Organophosphate and carbamate insecticides kill insects by--

____ a. Disrupting the growth hormone balance.
____ b. Disrupting chitin synthesis
____ c. Inhibiting cholinesterase
____ d. All of the above

ANSWERS - LESSON 6

1. a
2. c
3. a
4. c
5. a, b, d, f
6. d
7. b
8. b, d
9. c
10. a
11. a.
12. b
13. c
14. c
15. a
16. b
17. b
18. c
19. a
20. a
21. c

LESSON 7

PESTICIDE APPLICATION EQUIPMENT, AND CALIBRATION

A. INTRODUCTION

The equipment you use is important to the success of any pest control job. You must first select the right equipment. Then you must use it correctly to suit your needs -- and take good care of it. These rules apply whether you use hand-carried, tractor- mounted, or aircraft-mounted equipment.

B. TERMS YOU NEED TO UNDERSTAND

How well do you know some of the terms that are important in the use of pesticides? Test your knowledge of them by writing down the definitions for the terms below. To check your answers, refer to the glossary.

1. g.p.m.

2. p.s.i.

3. Orifice

4. g.p.a.

5. Coverage

6. Swath

7. Drift

8. Volatility

9. Inversion

10. Residual pesticide

11. Corrosive

C. DISCUSSION

DRIFT

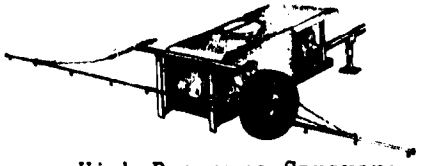
Many factors affect the ability of a pesticide applicator to effectively place the pesticide on target, with minimal movement of the spray or dry materials off target. Drift is influenced by many factors, of which the equipment and application methods are key factors. Spray pressure, nozzle and spray tip design and size directly influence drift. Some of the other factors influencing drift are wind speed, temperature, humidity, height of spray release, volatility of the pesticide, etc. We would expect spray drift to increase as the size of the spray droplets decrease, temperature increases, wind speed increases, and spray height increases.

APPLICATION EQUIPMENT

The following sections discuss some of the things you should know when choosing, using, and caring for application equipment.

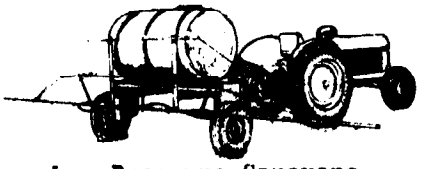
Hand Sprayers

Hand sprayers are used to apply pesticides for small jobs. You can use them in areas where a power unit is not practical. The advantages of hand sprayers include their low cost, simple construction and ease of use.



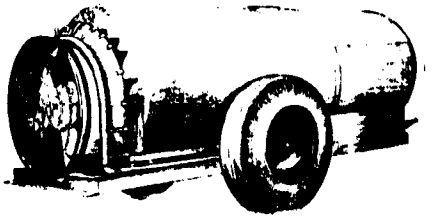
High-Pressure Sprayers

These devices are often called hydraulic sprayers. They are designed to deliver large volumes at a high pressure (50+ psi.). They are generally used to spray fruits, vegetables, trees, landscape plants, and livestock. Applications usually are made at a high volume (100 or more gallons per acre). The high pressure reduces the droplet size, resulting in increased drift possibilities.



Low-Pressure Sprayers

These sprayers are designed to deliver low to moderate volumes at 15 to 50 psi. Most of them are used on fields, forest areas, pastures and fence rows. The low pressure can reduce drift possibilities by producing large spray droplets.



Air Blast Sprayers

These units use a high speed, fan-driven airstream to break the nozzle output into fine drops, which move with the airstream to the target. The air is directed to either one or both sides as the sprayer moves forward. These sprayers are used on landscape plants, fruits, vegetables, and seed orchards.

Ultra-Low-Volume (ULV) Sprayers

These sprayers deliver undiluted pesticides to the target. Drift can be a problem because the droplets are usually very small.

Aerial Sprayers

Airplanes. -- Over 7,000 airplanes are used to apply pesticides in the United States each year. Aerial application is fast, convenient and fairly economical. Airplanes can be used over areas that cannot be traversed by ground equipment. However, airplanes usually cannot efficiently treat small areas, and are limited by power lines, highly populated areas, and adverse weather conditions. Some of the pesticides released from aircraft may drift, which can pose a problem in or near populated areas. The larger uses are in agriculture, and right-of-way work.

Helicopters. -- Helicopter application costs are usually more than for airplanes. However, helicopters offer certain advantages: They can operate without an airport, are less affected by weather conditions, offer less drift potential, high accuracy in the placement of the chemical and work much faster than ground methods.

SPRAYER PARTS

Tanks

Tanks should have large openings for easy filling and cleaning. The tank should be made of corrosion-resistant material such as stainless steel or glass-reinforced plastic. The tank should have a good drain. The outlets should be sized to the pump capacity. All tanks should have a gauge to show the liquid level.

Flush out the tank, pump, lines, and nozzles after each day's use, and after

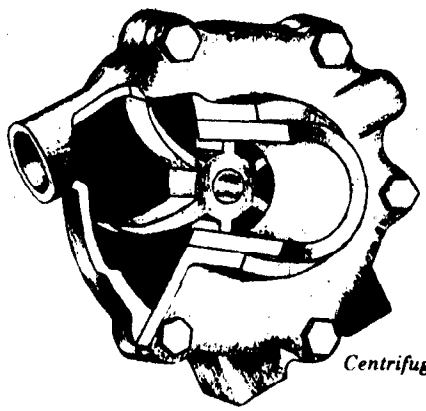
each separate pesticide use. If switching to another pesticide where contamination must be prevented, wash out the tank with detergent and water two or three times and then flush with water. Some herbicides, such as 2.4-D, are hard to remove. After using them, follow the special cleaning procedures noted on the pesticide label. Spray tanks should be equipped with agitation mechanisms. By pass agitation is usually sufficient for solutions, soluable powders, and emulsifiable concentrates. For invert emulsions mechanical agitation is required. Jet or mechanical agitation is needed for wettable powers.

Pumps

The pump is the heart of a spraying Unit. Pumps should resist corrosion and abrasion. Three kinds of pumps are most often used with sprayers, and are described below.

Centrifugal Pump

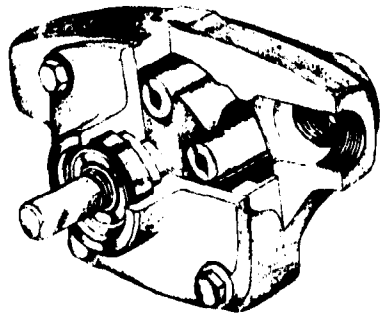
These pumps provide a high volume of spray at a low pressure. They are not often self priming. Some newer models claim priming ability.



Centrifugal Pump

Roller Pump

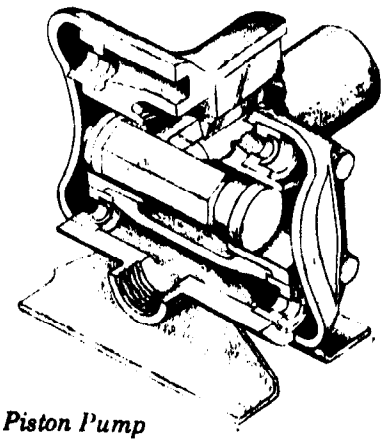
Roller and gear pumps provide a moderate volume of spray at a low to moderate pressure. They are self-priming in most equipment. Powder formulations should not be used in gear pumps.



Roller Pump

Piston Pump

These pumps provide low to moderate volumes of spray at a high pressure. They are self-priming. If you need high pressures, piston pumps are more likely than other pumps to do consistant work over a long period of time.



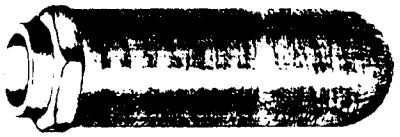
Piston Pump

CAUTION DO NOT OPERATE PUMPS WHEN TANK IS DRY.

Strainers (Filters)

Proper filtering of the pesticide protects the working parts of the spray unit and prevents clogging of spray tips.

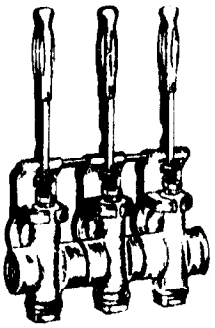
Clean strainers after each use. Replace them if they show signs of wear. Strainers are your best defense against nozzle or pump wear and nozzle clogging. Use nozzle screens as large as the nozzle sizes permit. Screen openings should be less than nozzle openings.



Strainer

Control Valves

These valves should be chosen in a size that does not restrict flow. They should be easy for you to reach. On-off action should be quick and positive.



Control Valves

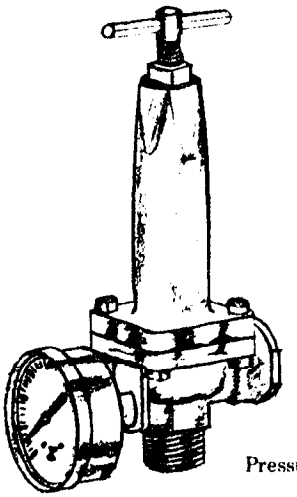
Hoses

Select synthetic rubber or plastic hoses that have a burst strength greater that the peak operating pressures of the pumping system being used. The hose must be able to resist damage from solvents present in pesticides. Suction hoses must resist collapse; they should be larger than pressure hoses. Replace hoses at the first sign of wear.

Hose

Pressure Regulators

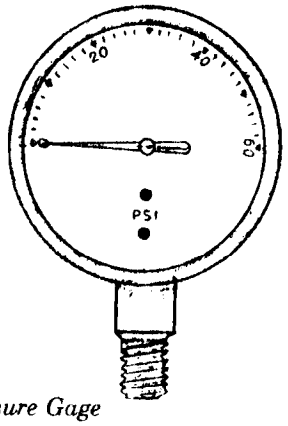
The pressure regulator should have a working range that is about the same as the range of pressure you plan to use.



Pressure Regulators

Pressure Gauge

These gauges serve as the pressure monitor for the spraying job. They must be accurate and should be designed to function over only the range needed for your work. Check frequently for accuracy.

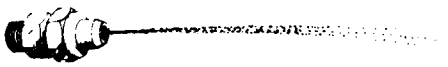


Pressure Gage

NOZZLES

Types of Nozzles

The nozzle is one of the most important parts of a sprayer. The nozzle helps control the rate, droplet size, uniformity, coverage, and safety of the pesticide application. Nozzle performance is the key to effective and efficient performance of the entire sprayer system. Eight kinds of nozzles are discussed in the following sections.

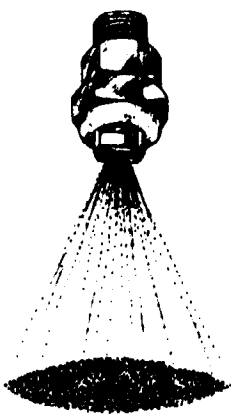


Solid Stream

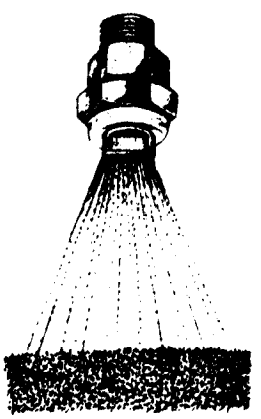
These nozzles are used in handguns to spray a distant target. They are also used to treat cracks and crevices in buildings. Other uses include thinline basal application and soil-active herbicide spot application.

Flat Fan

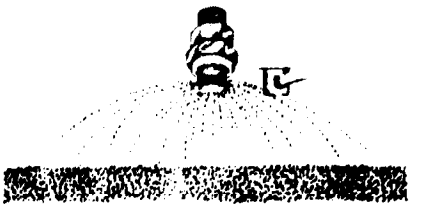
There are three types of flat fan nozzles:



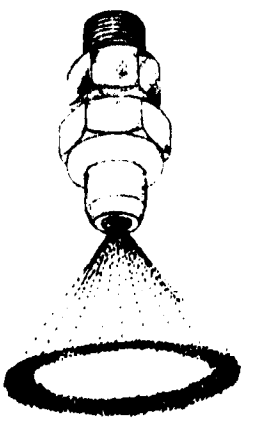
- The regular flat fan nozzle makes a narrow, oval pattern, with lighter edges. This nozzle is used for broadcast spraying, usually with an overlap of 30 to 50 percent for even distribution.



- The even flat fan nozzle produces a uniform pattern across its width. This nozzle is used for band spraying and treating other surfaces.

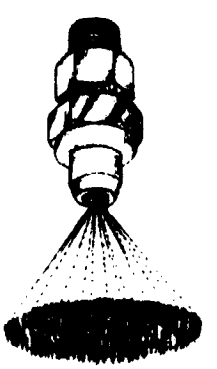


- The flooding nozzle makes a wide-angle flat spray pattern. This nozzle works at lower pressures than the other flat fan nozzles. The flooding nozzle has a fairly uniform pattern across its width.



Hollow Cone

There are two types of hollow cone nozzles: The core and disk, and the whirl chamber. The spray pattern is circular with tapered edges and little or no spray in the center. The hollow cone nozzle is used mostly for spraying foliage.



Solid Cone

This nozzle produces a circular pattern. The spray is fairly well

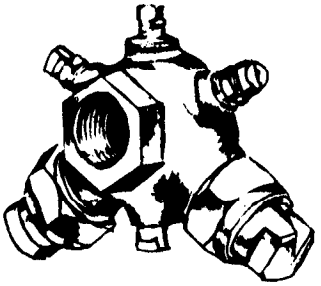
distributed throughout the pattern. The solid cone nozzle is also used for spraying foliage.

Broadcast

This nozzle forms a wide, flat, fan pattern. Broadcast nozzles are used on boomless sprayers and to extend the effective swath width when attached to the end of a boom.

Atomizing Nozzle

This nozzle creates a fine mist from liquid pesticides. Atomizing nozzles are used indoors in special situations. Fine spray droplets are created so drift can easily become a problem.



Cluster Nozzles are used either with a boom or at the end of booms to extend the effective swath width. One type is simply a large flooding deflector nozzle that will spread spray droplets over a wide swath. Cluster nozzles are a combination of a center-discharge and two or more off-center discharge fan nozzles. The spray droplets vary in size from very small to very large, so drifting can be a problem. Some of these nozzles use only off-center tips, which produce rather large droplets, so drift problems are less.

Offset

These nozzles lack the uniformity of the flat fan, but can provide reasonably uniform coverage over wide areas. They are often used to control weeds along roadsides, ditchbanks, and in some forestry ground sprayers.

There are many specialized spray nozzles and tips. For aerial applications there are the Raindrop, Microfoil, Flow Through Valve nozzles, etc.

About Nozzle Tip Numbers

Nozzle tip numbers are somewhat uniform among the various manufacturers. Generally, the first two numbers refer to the angle of spray discharge for flat tips. The last number(s) refer to the gallons per minute of the nozzle tip at 40 psi. For example, nozzle tip number 7 means a nozzle tip with a 75 degrees angle discharge and delivering of 0.058 gpm at 40 psi. The decimal point is placed by counting three figures from the left to the right, i.e. a Tee Jet 6005 tip delivers 0.5 gpm. One exception to the above is for angles 100 degrees or more.

Other nozzles and their uses are described in spray equipment catalogs.

Nozzle Materials

You can get nozzles in many materials. All the materials should resist abrasion and corrosion for planned applications. The main features of five materials are discussed in the following sections.

Brass:

-Inexpensive
-Wears quickly from abrasion
-Probably the best material for limited use
-Works well for most forest pesticide uses

Stainless steel:

-Fairly expensive
-Will not corrode
-Resists abrasions, especially if it is hardened

Plastic:

-Inexpensive
-Resists corrosion and abrasion
-Can swell when exposed to some pesticide solvents

Aluminum:

-Resists some corrosive materials
-Is easily corroded by some fertilizers
-Wears rather quickly from abrasion.

Tungston carbide and ceramic:

-Highly resistant to abrasion and corrosion
-Expensive

Nozzles must be kept in good working condition for accurate application.

OPERATION AND MAINTENANCE

Always read and follow the operator's manuals for all spray equipment. The manuals will tell you exactly how to use and care for each piece of the equipment. After each use, clean and rinse out the entire system. Clean the nozzle tips and strainers. Wear appropriate protective clothing and use suitable materials while cleaning or making repairs.

OTHER TYPES OF EQUIPMENT

Foggers, mist blowers, and aerosol generators. -- These devices break the pesticide liquid into very small droplets. The large number of particles is visible as a cloud of fog. Extreme caution must be taken as aerosols, mists, and fogs easily drift from target areas, often for miles.

Granule applicators. -- This equipment applies coarse, dry uniform particles to soil or water. This equipment is available in three types -- hand, ground or aerial applicators.

Low-volume air sprayers. --These sprayers are often called mist blowers. They are characterized by high velocities and a somewhat lower water volume than conventional air-blast sprayers. Extreme caution must be taken to avoid drift.

Ultra-low volume sprayers. This equipment applies the chemical concentrate directly. Extreme caution must be taken to avoid drift.

Some other equipment includes wiper applicators, roller applicators, etc. These types of equipment are continually increasing in use as viable application methods.

SOIL FUMIGATION EQUIPMENT

The equipment needed for applying soil fumigants depends on the kind of fumigant being used. There are two kinds of fumigants:

1. Low-pressure (low-volatility) liquid fumigants. These fumigants usually use the soil itself, or water, to keep the fumigant from vaporizing and moving off target too quickly. Some of the methods used are:

   - Soil injection. -- This method uses a variety of devices to insert the fumigant into the soil (usually 6 inches deep or more). The device then covers the area with soil again to seal in the fumigant.

   - Soil incorporation. -- This method is used to apply low-volatity fumigants. The fumigant usually is sprayed onto the soil surface. The area is immediately cultivated, usually to a depth of 5 inches or less.

2. Highly volatile fumigants. These chemicals remain as liquids only when placed under pressure. Effective

application of highly volatile fumigants depends on tightly sealing the soil with tarps, plastic film, or similar covers.

There are two major methods of using vapor-proof tarps:

- Tarp supported off the ground and sealed around the edges; a fumigant is put under the tarp.

- Tarp applied to the soil by the injection chisel applicator immediately after the fumigant is injected.

Highly volatile fumigants must be handled in closed, pressurized containers or tanks, and extreme care must be taken during application to ensure safety for the workers.

SEED TREATERS

Seed treaters are used to coat seeds with a pesticide. The three basic types of commercial seed treaters are:

1. Dust treaters

2. Slurry treaters

3. Liquid treaters

CALIBRATION

Calibration is the process of measuring and adjusting your equipment to apply the desired rate of pesticide. Proper calibration is necessary, but too often is neglected or done in haste. If too much pesticide is applied, the labeled amount may be exceeded. The result is excessive costs, illegal residues, possible danger to the workers and the environment, and lawsuits or fines. At the other extreme, too little pesticide can result in inadequate control, and the added cost of having to re-do the job. Only by correct calibration can you safely and consistently get the best results.

Before you begin any calibration procedures, carefully check all the equipment to be sure all components are clean, and in good working condition. There are many kinds of application equipment, all differing in details of operation. However, if you understand the basics of calibration, you can apply this knowledge in any situation. Also, always read the equipment manufacturer's instructions before beginning calibration.

Calibration is not a difficult process. Almost everyone can do the simple arithmetic without any problems. You can do the job even faster if you have a pocket calculator.

Pumping Rate

To determine the pumping rate of your sprayer, fill the tank to a known level with water. Set the spray pressure at the desired level, and allow the unit to spray for a few minutes to remove all air from the system. Then check the pressure again while the unit is spraying. Collect the spray in a bucket or drum for about 5 minutes or refill the tank to the original level, measuring the gallons required. The reason for timing this step at 5 minutes or more is to get a more exact measurement then you would get by trying to measure for only 1 minute. Divide the gallons collected (or used to refill the tank) by 5 minutes to determine the pumping rate.

Example:

$$\frac{20 \text{ gallons}}{5 \text{ minutes}} = 4 \text{ gallons per minute}$$

You may also determine the rate for each spray trip by following the above method.

Field Sprayer Calibration

If you know the pumping rate, speed and width of the spray equipment, then the rate per acre is easily determined.

One method of calibration is shown below, but there are many others. The

facts you must know for this method are:

-- 1 acre = 43,560 square feet.

-- The distance the sprayer moves in 1 minute at an established speed.

-- The width of the spray.

-- The rate of the spray.

Example #1

Suppose the width of the spray is 20 feet, and the distance covered is 440 feet in 1 minute, and the spray rate is 4 gallons each minute.

Figure the area the sprayer covered in 1 minute (distance x spray width).

440 feet per minute x 20 feet = 8,800 square feet per minute.

Then calculate how many minutes it would take to spray 1 acre. Divide 43,560 square feet per acre by 8,800 square feet per minute.

$$\frac{\text{43,560 square feet per acre}}{\text{8,800 square feet per minute}}$$

= about 5 minutes per acre

Then, figure the amount of spray per acre: 4 gallons per minute x 5 minutes per acre = 20 gallons per acre.

Determine how much pesticide to put in the tank:

You know now how many gallons of spray per acre your equipment can apply (20). Next, determine how much pesticide to put into the tank to apply the correct rate of material. Here are two more facts you need to know:

-- How many gallons the sprayer tank holds.

-- The amount of formulation to be used per acre.

or

-- The amount of active ingredient per gallon of formulation and the amount of active ingredient to be applied per acre.

Example #1a

The spray tank holds 200 gallons and you wish to apply 1 gallon of formulated product on each acre. You have already determined that the sprayer applies 20 gallons per acre. First, find the number of acres one tank will spray. Divide 200 gallons (capacity of tank) by 20 gallons per acre.

$$\frac{\text{200 gallons per tank}}{\text{20 gallons per acre}}$$

= 10 acres per tank.

Then find the total amount of formulated product to be added to the tank by multiplying 1 gallon per acre times 10 acres per tank = 10 gallons.

Example #1b

Let's, suppose the formulated product contains 4 pounds active ingredient per gallon and you want to apply 2 pounds of active ingredient per acre. Again a tankful covers 10 acres.

First, determine how much formulated product is in 1 quart. We know there is 4 pounds of active ingredient in 1 gallon and 4 quarts in 1 gallon; therefore, there are 4 pounds in 4 quarts, so there is 1 pound in each quart.

$$\frac{\text{4 pounds}}{\text{1 gallon}} = \frac{\text{4 pounds}}{\text{4 quarts}}$$

$$\frac{\text{1 pound}}{\text{1 quart}} = \frac{\text{2 pounds}}{\text{2 quarts}}$$

Because you want to apply 2 pounds of active ingredient (2 quarts) per acre, multiply 2 quarts times 10 acres per tankful.

2 quarts x 10 acres per tankful = 20 quarts or 5 gallons per tankful to achieve 2 pounds of active ingredients per acre.

In this example, if the 2 pounds of active ingredient were a 50 - percent wettable powder, then you would have to double (4 pounds) the product to apply 2 pounds of active ingredient per acre.

Changing the Delivery Rate

If the sprayer delivers more (or less) than the desired rate per acre, you can change the rate by basically three methods:

-- Change the pump pressure. Lower pressure, of course, means less spray volume, and higher pressure means more spray delivered. This method will change the spray tip pattern, which includes the spray width. The pressure must be increased 4 times to double the output, or decreased 4 times to cut the output in half.

   Example

   If the pressure increased from 20 psi to 80 psi, the spray volume can increase from 20 gpa to 40 gpa.

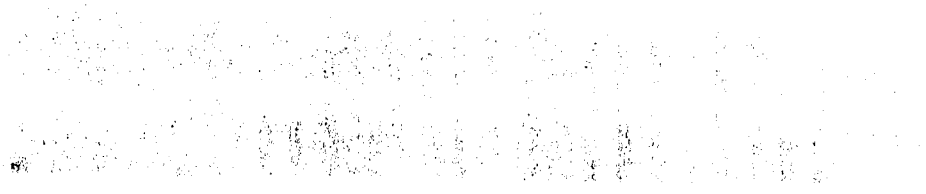
-- Change the speed of the sprayer. A slower speed means more spray will be delivered. A faster speed means less spray will be delivered. If the speed is doubled, the spray rate per acre is cut in half, or if the speed is decreased by one-half, the rate per acre will be doubled.

   Example

   Tractor speed decreases from 4 mph to 2 mph, so the rate per acre can be increased from 20 gpa to 40 gpa.

-- Change the nozzle spray tips. The larger the hole in the tip, the more spray delivered and, of course, the smaller the hole, the less spray delivered.

Calibrate a granular applicator with the same procedure, but weigh the granules.



SELF TEST

AND

ANSWERS

LESSON 7
Self-Test

1. You would expect spray drift to be greater when which condition exists?

_____ a. The wind speed increases and spray droplet size increases
_____ b. The wind speed decreases and spray droplet size increases
_____ c. The wind speed increases and spray droplet size decreases
_____ d. The wind spped decreases and spray droplet size decreases

2. The higher the sprayer pressure --

____ a. The larger the droplet size
____ b. The smaller the droplet size
____ c. Droplet size remains the same
____ d. Output is reduced

3. In terms of drift control, nozzle tips are as important as the spraying pressure.

____ a. True
____ b. False

4. When selecting a pump, you should consider --

____ a. The ability of the pump to resist corrosion and excess wear
____ b. The range of operating pressure for your work
____ c. The capacity, in gallons per minute or per hour.
____ d. All of the above

5. Match these:

____ a. Piston pump
____ b. Roller pump
____ c. Centrifugal pump

1. Moderate volume at low to moderate pressure
2. High volume at low pressure
3. High pressure.

6. The pressure guage maintains the required pressure in a system.

____ a. False
____ b. True

7. The heart of a spraying unit is --

____ a. pump
____ b. nozzle
____ c. regulator
____ d. In-line strainer

8. Which of these nozzles would be used in overlapping groups for broadcast spraying?

____ a. even flat fan
____ b. regular flat fan
____ c. full cone
____ d. solid stream

9. Match the following:

____ # a

1. Evan flat fan
2. Hollow cone
3. Broadcast
4. Solid stream
5. Regular flat fan
6. Solid cone
7. Flooding nozzle

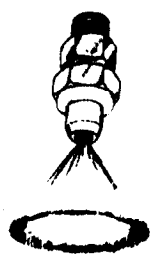
____ # b

____ # e

____ # c

____ # f

____ # d



____ # g

10. There are several types of flat fan nozzles. The regular flat fan nozzle makes a flat oval pattern with light edges.

    Which picture shows this regular flat pattern?

____ a ____ b

11. Which nozzle type would be more accurate for aiming at distant targets?

    ____ a. Solid stream
    ____ b. Flat fan
    ____ c. Cone

12. When choosing nozzle material you should consider --

    ____ a. Abrasion
    ____ b. Corrosion
    ____ c. Cost
    ____ d. All of the above

13. Match these:

____ a. Brass	1. Can swell when exposed to some solvents
____ b. Stainless steel	2. Best material for extensive use, resists abrasion
____ c. Plastic	3. Best material for limited use, such as forestry applications.
____ d. Aluminum	4. Corroded by some fertilizers
____ e. Tungston carbide and ceramic	5. Expensive

14. Nozzle tip numbers are fairly standard among the different manufacturers. The first two numbers refer to the angle of spray discharge. The last number(s) refer to the gallons per minute that can flow through the nozzle tip at 40 psi. A nozzle tip with this number, 630082, means --

    ____ a. A nozzle tip with a 82 degree angle of fan discharge
    ____ b. A nozzle tip with a 63 degree angle of fan discharge delivering .0082 gallons
    ____ c. A nozzle tip with a 6.3 degree angle of fan discharge and delivering .82 gallons per minute.
    ____ d. A nozzle tip with a 63 degree angle of fan discharge and delivering 0.082 gallons per minute.

15. A nozzle with tip number 350150. --

____ a. 150 degree angle of discharge
____ b. 35 degree angle of discharge and delivering 0.150 g.p.m.
____ c. 35 degree angle of discharge and delivering 15 g.p.m.
____ d. 35 degree angle of discharge and delivering 1.5 g.p.m.

16. A mist blower produces large spray droplets, so drift should not be of concern.

____ a. True
____ b. False

17. Which of the following will change pesticide application rates?

____ a. Change sprayer pressure.
____ b. Change in spray tip size.
____ c. Change in applicator speed.
____ d. All of the above.

18. You can double the sprayer output by:

____ a. Cutting sprayer pressure in half.
____ b. Increasing sprayer pressure 2 times.
____ c. Increasing sprayer pressure 4 times.

19. A sprayer is calibrated to apply 15 gallons per acre (gpa) at a speed of 4 miles per hour. What would be the application rate if the sprayer were slowed to 2 miles per hour?

____ a. 7.5 gpa.
____ b. 30 gpa.
____ c. 20 gpa.

20. A sprayer is calibrated to apply 15 gallons per acre at a pressure of 20 psi. What is the pressure required to increase the output to 30 gallons per acre without a change in speed, or spray tip size.

____ a. 40 psi.
____ b. 10 psi.
____ c. 80 psi.

21. The spray directions required 8 gallons of a herbicide for a 200 gallon spray solution. If you only wanted to mix 50 gallons of the spray solution, how many gallons of the herbicide would be needed?

____ a. 2 gallons.
____ b. 3 gallons.
____ c. 4 gallons.

22. You want to apply 1 1/2 gallons of a pesticide per acre in 25 gallons of water. How many gallons of the pesticide would you need for 30 acres?

____ a. 50 gallons.
____ b. 45 gallons.
____ c. 15 gallons.

23. The spray rate is 3 gpm, the spray width is 40 feet, and the sprayer travels 200 feet in 2 minutes. What is the spray rate in gallons per acre?

____ a. 40.
____ b. 20.
____ c. 33.

ANSWERS - LESSON 7

1. c

2. b

3. a

4. d

5a. 3
b. 1
c. 2

6. a

7. a

8. b

9a. 4
b. 5
c. 1
d. 2
e. 6
f. 3
g. 7

10. a

11. a

12. d

13a. 3
b. 2
c. 1
d. 4
e. 5

14. d

15. b

16. b

17. d

18. c

19. b

20. c

21. a

22. b

23. c

LESSON 8

INVERTEBRATE PESTS ("BUGS", SNAILS AND SLUGS)

A. INTRODUCTION

The most important step in solving any problem is to understand the cause. So the first step in your job is to recognize the invertebrate pest you need to control.

There are hundreds of thousands of different kinds of insects, mites, spiders, ticks, snails and slugs, but only about 100 species that do much damage. Identification aids, pictures, and publications help to identify these pests.

B. TERMS YOU NEED TO UNDERSTAND

How well do you know some of the terms that are important in the use of pesticides? Test your knowledge of them by writing down the definitions for the terms below. To check your answers, refer to the glossary.

1. Larva

2. Pupa

3. Nymph

4. Metamorphosis

5. Insecticide

6. Acaricide

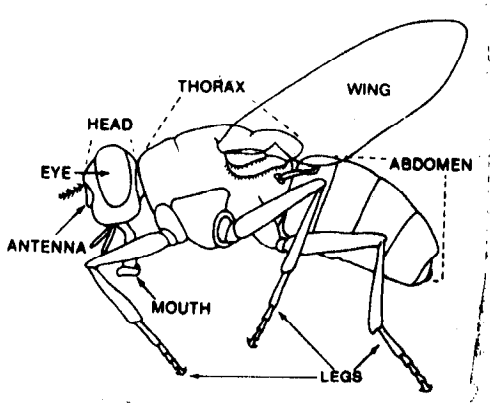
7. Miticide

8. Molluscicide

9. Threshold

C. **DISCUSSION**

INSECTS



Insects thrive in more environments than any other group of animals. They live on the earth's surface within the soil and in water. They survive in deserts, rain forests, hot springs, snow fields, and dark caves.

Many types of insects affect crops. They cause damage in a variety of ways. They may:

- feed on leaves,
- tunnel or bore in stems,
- feed on and tunnel in roots,
- feed on and in seeds and nuts,
- suck the sap from leaves, stems, roots, fruits, and flowers, and,
- carry plant disease agents.

The plants can be damaged, weakened, or killed. This causes reduced yields and lowered quality. Even after harvest, insects may continue their damage in the stored or processed products. Insects also feed on and in man and other animals. Some of these pests spread diseases which have killed millions of people and animals.

Not all insects are pests. Some help us by doing such things as pollinating plants or feeding on other insects that are pests.

Common Features of Insects

Insects have two things in common--they have <u>six</u> jointed legs and <u>three</u> body regions - head, thorax and abdomen. How can you tell one insect from another? The most important parts to look at are the wings and mouth. Some insects have no wings. Others have two or four. The wings vary in shape, size, thickness, and structure. Insects with chewing mouth-parts have toothed jaws that bite and tear the food. Insects with piercing-sucking mouth-parts have a long "beak" which they force into a plant or animal to suck out fluids or blood.

The marks left by insect, feeding, and the resulting damage to plants and animals, often provide reliable clues that help identify the pest.

A specialist in this field should be consulted if you need help to identify an insect or insect-related problem. You may be able to secure this assistance from your Region's Forest Pest Management (FPM) staff, State Forester's (FPM) staff, extension or Farm Bureau specialists, colleges, etc.

Almost all insects change in shape, form, and size during their lives. This change is called metamorphosis.

Some insects change only in size as they develop. The adult lays eggs, which develop into nymphs.

A nymph, which looks like a tiny adult, hatches from the egg and goes wingless through several molts before becoming an adult.

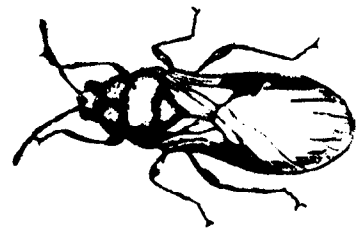
Some insects change form slightly. Their nymphs, which have no wings, go through several growing stages. They then change into winged adults.

Other insects change completely. They go through four stages. The larva hatches from an egg. It is a worm, caterpillar, grub, or maggot. This is the stage in which these insects grow the most and often do the most damage. When full-grown, the larva changes into a pupa. During this resting stage it changes into the adult. The adult stage usually has wings.

Here are the insect groups that include many of the insects that humans consider pests. You should study the characteristics of each group.

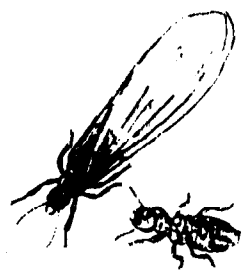
Grasshoppers, crickets and cockroaches

- Some have wings; some do not have fully developed wings. The top pair of wings is leathery.
- Chewing mouthparts
- Young and adults look alike, but the young lack developed wings.
- Grasshoppers usually feed on plant leaves and stems.
- Crickets are found in the field or indoors. They eat almost anything made from plants.
- Cockroaches often live in restaurants, houses, stores and offices. They eat the same foods as people.



True Bugs

- Some have wings; some do not. The top pair of wings is part leathery and part transparent.
- Piercing-sucking mouthparts.
- Young and adults look alike, but the young lack developed wings.
- Suck the juice from plants, and blood from man and animals.
- Reduce the vitality and yield of plants and animals, and may carry plant and animal disease agents.



Termites

- Swarming termites have four wings of equal size and shape; other termites are white and have no wings.
- Chewing mouthparts.
- Young and adults look alike.
- Usually feed on wood products such as fence posts, timbers, and flooring.
- Damage to the wood in homes and other structures is common.

Bees, Wasps, Ants and Sawflies

- Most adults have a narrow waist; sawflies are an exception.
- Some have four wings; some have none.
- Chewing mouthparts.
- Most young are wormlike, with no legs. The young of sawflies look like caterpillars.
- Young are usually found in nests made of soil, mud, paper or wax.
- Painful stings from many adults make some of these a pest.
  Others may damage wood products.

Beetles

- Adults have two top wings that are usually hard and shiny; the bottom wings are transparent.
- Chewing mouthparts
- Young are grubs or worms
- Some young have no legs; others have six.
- Young and adults are found on plants, in soil, and in wood buildings.
- Both the adult and larval stages may damage stored food products, plants, and in some cases, animals and animal products.

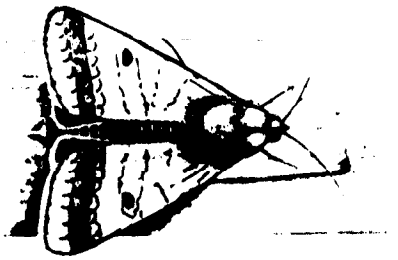
Aphids, Leafhoppers, Spittlebugs, and Scale Insects

- Some have wings; some do not.
- Piercing-sucking mouthparts.
- Young of aphids, leafhoppers, and spittlebugs look like the adults.
- Adult scale insects are scale-covered and stay in one place on the plant.
- Nymphs may damage leaves, stems, roots, fruit, and cloth.
- Suck the juices from plants.
- Reduce the vitality and yield of plants.
- Some carry plant disease agents.

Flies and Mosquitoes

- Adults have only two wings (other winged insects have four).
- Mouthparts of adults are piercing-sucking, but may be slightly modified for sponging, rasping, or cutting.
- Young (except mosquitoes) are maggots.
- Head of young usually not well-defined; mouthparts are small, dark, and hooklike.
- Young mosquitoes live in water.
- They have a well-developed head, with chewing mouth-parts.

- Maggots usually feed on plant seedlings and roots, in organic matter, in water, and in other damp places.
- Some maggots feed on animals.
- Some adults carry disease agents.



Moths and Butterflies

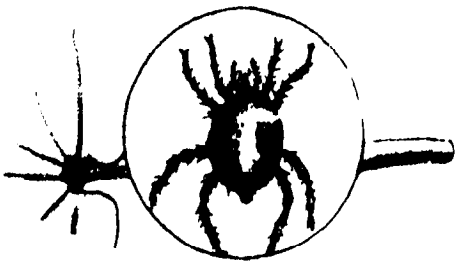
- Most adults have four large wings with many scales that rub off easily.
- Most moths are dull brown; butterflies are brightly colored.
- Mouthparts of some adults are lacking or are a coiled tube used for sucking.
- Larvae are caterpillars, usually with six joined legs and 10 soft, fleshy parts that look like fat legs.
- Larvae have chewing mouth-parts.
- Larval stages may damage leaves, stems, tubers, fruit, and cloth.

MITES, TICKS and SPIDERS

Common Features

Mites, ticks and spiders rival the insects in number of species and in the variety of places they live. They live on the ground (terrestrial), in the water (aquatic), in the soil, and in organic debris, where they usually outnumber other arthropods. Many mites and ticks are parasitic, at least during part of their lives; others are free living. They are annoying pests and some transmit diseases. Spiders rarely bite people, but a few are very poisonous.

Mites, ticks and spiders are closely related to insects. The main differences are that the adults have eight jointed legs instead of six and have two body regions. They do not have wings. The two body regions of spiders are separated by a slender stalk, unlike ticks.

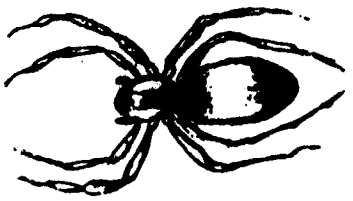


Mites

- Adults and nymphs have eight legs; larvae have six,
- Very small--about the size of the period at the end of this sentence.
- No wings
- Injury they cause usually is noticed before the mites are found.
- Sucking mouthparts.
- Soft-bodied.
- Some mites make thin webs on plants.
- When present on plants in large numbers, their feeding turns foliage and buds whitish, reddish, or brown. Some may scar fruit.
- On animals, they cause severe skin irritation, redness, scabs, scaliness.
- Chiggers (also called red bugs) are mites that attack humans.

Ticks

- Adults and nymphs have eight legs, larvae have six.
- Leathery or soft body (sometimes colored) without a distinct head.
- Piercing-sucking mouthparts with which they firmly attach themselves to the host animal.
- Parasitic on animals, including humans.
- Must have blood to complete their life cycle.
- Some carry disease agents to humans and animals.



Spiders

- Eight legs.
- Biting mouthparts.
- Vary in length from a fraction of an inch to 5 or 6 inches.
- Useful because they eat insects, but their webs and excretions may be a nuisance.
- Black widow and brown recluse spider bites are dangerous to humans.

SNAILS AND SLUGS

Common Features

Snails have a hard shell, slugs have no shell. Snails and slugs have rasping mouthparts.

Snails and slugs are members of a large group of animals called mollusks. They are among the most familiar invertebrate animals. They live in a large variety of habitats. They have invaded marine water, fresh water and land habitats. They serve as food for many other animals, including humans. Some land snails and slugs do extensive damage to crops and ornamental plants. Slugs attack both the aerial and underground portions of plants. They are pests in lawns, landscape plantings, and greenhouses.

SELF TEST

AND

ANSWERS

LESSION 8

Self Test

1. Adult mites, ticks and spiders have —

___ a. Three pair of wings.
___ b. Four body regions.
___ c. Eight jointed legs.
___ d. None of the above.

2. Insects differ from other animals in the following characteristic —

___ a. Sucking, chewing, or biting mouthparts.
___ b. Six jointed legs.
___ c. Two body sections.
___ d. Two wings.

3. The more important common features to look at when identifying an insect are the—

___ a. Legs and antennae.
___ b. Coloration and mouthparts.
___ c. Antennae and size.
___ d. Wings and outward mouthparts.

4. Insects grow the most during which stage of their life cycle—

___ a. Larval
___ b. Pupal
___ c. Egg
___ d. Adult

5. Snails and slugs can be distinguished from one another because —

___ a. Slugs have a shell and snails don't.
___ b. Slugs and snails feed mostly on insects.
___ c. Snails are a member of the mollusk group of animals; slugs are not.
___ d. Snails have a shell and slugs don't.

6. Mites, ticks, and spiders live —

___ a. on the ground, and in ground
___ b. in the water
___ c. in organic debris
___ d. All of the above

7. One of the organisms below has three body regions and six jointed legs --

___ a. Sawflies
___ b. Spider
___ c. Mite
___ d. Tick

8. Ticks have --

___ a. Sucking mouthparts
___ b. Rasping mouthparts
___ c. Chewing mouthparts
___ d. Sponging mouthparts

9. If you have trouble identifying an insect, you should --

___ a. Apply a pesticide that is recommended for a similar pest.
___ b. Seek the help of an expert.
___ c. Ignore the problem as it will probably go away.
___ d. None of the above

10. One of the following is <u>not</u> an insect relative --

___ a. Ticks
___ b. Slugs
___ c. Spiders
___ d. Mites

11. An insect changes its form when it develops from an egg to an adult. This change is called --

___ a. Cyclical alteration
___ b. Transmutation
___ c. Metabolic growth
___ d. Metamorphosis

12. A stage in which insects usually do the most damage --

___ a. Pupa
___ b. Larva or nymph
___ c. Egg
___ d. None of the above

13. An insect's three body regions are --

___ a. Head, thorax and antennae
___ b. Head, wings, and legs
___ c. Head, wings, and abdomen
___ d. Head, thorax and abdomen

14. The larval stage for moths and butterflies is called --

___ a. Caterpillars
___ b. Clusters
___ c. Flyers
___ d. Nymphs

15. Match the following:

____ a. Acaricide	1. Insect looks like an adult, but the wings are not fully developed
____ b. Nymph	2. Stage between the larvae and adult
____ c. Metamorphosis	3. Used to kill mites and ticks
____ d. Pupa	4. An insect change in shape, form, and size

ANSWERS - LESSON 8

1. c
2. b
3. d
4. a
5. d
6. d
7. a
8. a
9. b
10. b
11. d
12. b
13. d
14. a
15a. 3
b. 1
c. 4
d. 2

LESSON 9

PLANT DISEASE AGENTS

A. INTRODUCTION

A plant disease is a condition in which a plant (host) and a disease-causing agent interact over time to the detriment of the host. This process may kill the plant; the plant may survive in a diseased condition; or the plant may recover. Biological agents (pathogens) that cause plant disease are of primary interest to pesticide applicators because these agents often can be controlled with pesticides. Pathogens include:

- fungi
- bacteria
- viruses and mycoplasmas, and
- nematodes.

Parasitic seed plants are sometimes considered pathogens because of the type of injurious response they evoke from the host plant.

B. TERMS YOU NEED TO UNDERSTAND

How well do you know some of the terms that are important in the use of pesticides? Test your knowledge of them by writing down the definitions for the terms below. To check your answers, refer to the glossary.

1. Pathogen

2. Infection

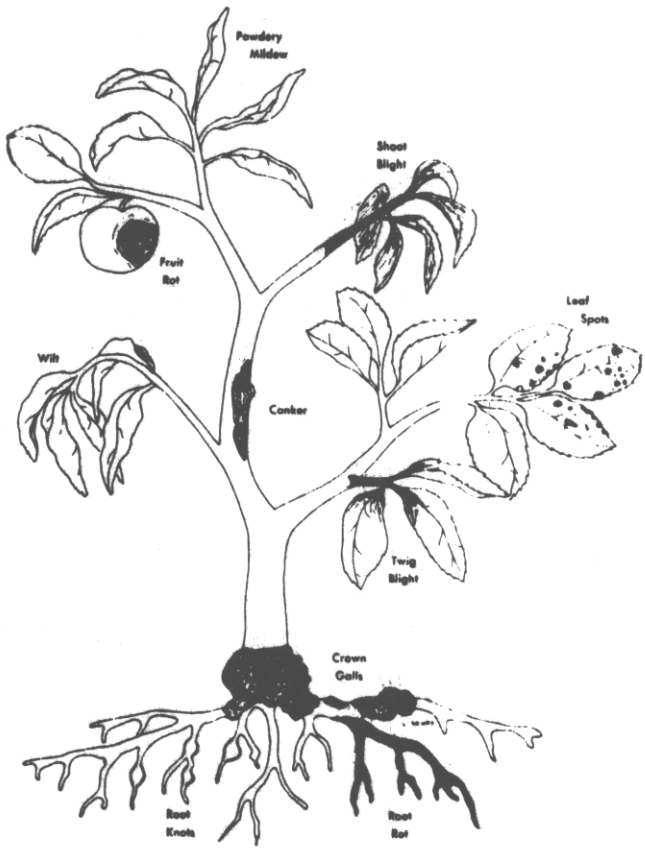
3. Fungicide

4. Fungicide

5. Host

6. Nematicide

7. Vector



Ways In Which Diseases Affect Plants

C. DISCUSSION

COMMON FEATURES OF PLANT DISEASES

Plant diseases are often divided into two groups -- nonparasitic and parasitic based on their cause.

Nonparasitic Plant Diseases

These diseases are caused by non-living agents. One-time damage, i.e., lighting, may injure a tree. Although such damage is not a real disease, injuries of this type are included here. Other examples include:

- nutrient deficiency,
- extreme cold or heat,
- toxic chemicals (air pollutants, some pesticides, salts, too much fertilizer),
- mechanical injury, and
- lack of, or too much, water.

These diseases cannot be passed from one plant to another.

Parasitic Plant Diseases

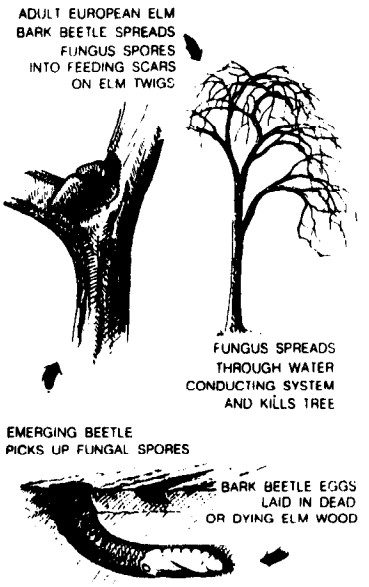
Pathogens that cause plant diseases are parasitic -- they live and feed on or in host plants, deriving nourishment and often protection from the host plant. They can move or be moved from one plant to another. The most common causes of parasitic diseases are --

- fungi,
- bacteria,
- viruses,
- mycoplasmas, and
- nematodes.

Insects can cause symptoms similar to those of a prasitic disease, as can a few seed-producing plants and some microbes.

Three things are required before a parasitic disease can develop --

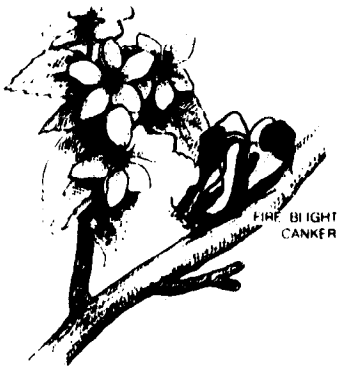
- a susceptible host plant,
- a parasitic agent, and
- an environment favorable for parasites to develop.


ADULT EUROPEAN ELM BARK BEETLE SPREADS FUNGUS SPORES INTO FEEDING SCARS ON ELM TWIGS
FUNGUS SPREADS THROUGH WATER CONDUCTING SYSTEM AND KILLS TREE
EMERGING BEETLE PICKS UP FUNGAL SPORES
BARK BEETLE EGGS LAID IN DEAD OR DYING ELM WOOD

DUTCH ELM DISEASE — DISEASE CYCLE

Fungi

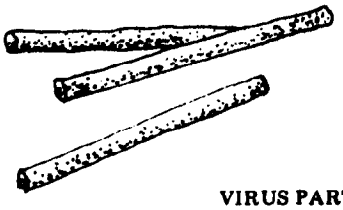
Fungi are plants that lack green color (chlorophyll). They cannot make their own food, so they get food by living on other organisms. Not all are harmful, many are helpful. All are microscopic, but many produce large fruiting structures such as mushrooms. Most fungi reproduce by spores, which function much like seeds. Fungi may attack a plant both above and below the soil surface. Some fungi cause problems through wood rot or discoloration. Root rot and stem galls are other examples of fungus diseases.



FIRE BLIGHT SHOWING SYMPTOM DEVELOPMENT FOLLOWING SPREAD OF BACTERIA FROM BLOSSOM TO LIMB

Bacteria

Bacteria are microscopic, one-celled plants. They usually reproduce by simply dividing in half. Each half becomes a fully developed bacterium. Bacteria can reproduce at a fast rate under ideal conditions. Some can divide every 30 minutes. Often witches'-brooms, stem galls or leaf spots are caused by bacteria.



VIRUS PARTICLES

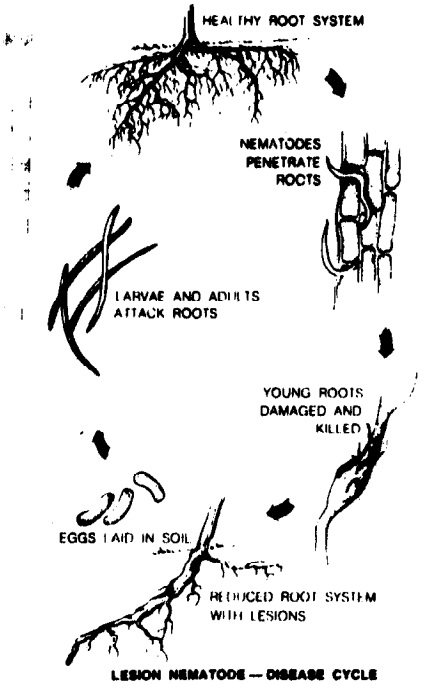
Leaf Spot/Picture

Viruses

Viruses are nonliving compounds. Even though they are nonliving, they are infectious. Once within the host, they produce more viral structures. They are so small that they cannot be seen with the unaided eye or even with an ordinary microscope. They are generally recognized by their effects on plants. Many viruses that cause plant disease are vectored by insects, usually aphids or leafhoppers. Viruses are easily carried along in bulbs, roots, cuttings, and seeds. Some viruses are transmitted when machines or workers touch healthy plants after touching diseased plants. A few are transmitted in pollen or by nematodes, and, at least one, by a fungus.

Mycoplasma-like Organisms

These living organisms are intermediate in size between bacteria and viruses. It has been discovered recently that they cause many plant diseases formerly thought to be viruses. These organisms are vectored by insects.


HEALTHY ROOT SYSTEM
NEMATODES PENETRATE ROOTS
LARVAE AND ADULTS ATTACK ROOTS
YOUNG ROOTS DAMAGED AND KILLED
EGGS LAID IN SOIL
REDUCED ROOT SYSTEM WITH LESIONS

LESION NEMATODE — DISEASE CYCLE

Nematodes

Nematodes are small, usually microscopic, roundworms, also called eelworms. Many nematodes are harmless. Others may attack crops and ornamental plants. Some species attack the above-ground plant parts, such as leaves, stems, and seeds. But most species feed on or in the roots. Nematodes usually do not kill plants, but reduce growth and plant health. They may weaken the plant and make it susceptible to other disease agents.

All nematodes that are parasites on plants have a hollow feeding stylet (specialized mouthparts). They use it to puncture plant cell walls and feed on the cell contents. Nematodes may develop and feed either inside or outside a plant.

Development of Plant Diseases

A parasitic disease depends on the life cycle of the parasite. The environment greatly affects this cycle. Temperature and moisture are especially important. They affect --

- the activity of the parasite,
- the ease with which a plant becomes diseased, and
- the way the disease develops.

The disease process starts when the parasite arrives at a part of a plant where an infection can occur. This step is called **inoculation**. If environmental conditions are good, the parasite will begin to develop. This stage -- where the pathogen is active, but the host is as yet unaffected -- is called **incubation**. **Invasion** is the process of attacking and penetrating living host material. **Infection** occurs when a food-based relationship is established between the host and pathogen. **Disease** begins when the host responds adversely to infection.

The three main responses of a host to diseases are:

- overdevelopment of tissue resulting in galls, swellings, or leaf curls,
- underdevelopment of tissue resulting in stunting, lack of chlorophyll, incomplete development of organs, etc., and
- death of tissue as in blights, leaf spots, wilting, and cankers.

Identifying Plant Diseases

We cannot always tell one plant disease from another by looking at the symptoms on the plant. Because many diseases produce similar symptoms, we need other evidence. Identifying the cause is the best way to identify the disease. A microscope is needed to see such things as fungal spores, nematodes or their eggs, and bacteria.

SELF TEST

AND

ANSWERS

LESSON 9

SELF TEST

1. A nonparasitic plant disease is --

   ____ a. a disease that can be passed from one plant to another.
   ____ b. a disease that cannot be passed from one plant to another.
   ____ c. a disease caused by fungi or bacteria.

2. Which of the following cause parasitic plant diseases --

   ____ a. nematodes
   ____ b. fungi
   ____ c. viruses
   ____ d. all of the above

3. Fungi are plants that --

   ____ a. have chlorophyll
   ____ b. live on other organisms
   ____ c. reproduce mostly by seeds

4. Which of these are required before a parasitic disease can develop --

   ____ a. a susceptible host
   ____ b. a parasitic agent
   ____ c. a favorable environment
   ____ d. all of the above

5. Nematodes --

   ____ a. are all harmful
   ____ b. are easily diagnosed
   ____ c. usually kill plants
   ____ d. can reduce plant growth and health

6. Temperature and moisture are <u>not</u> key factors in the development of parasitic diseases.

   ____ a. True
   ____ b. False

7. A nematode is --

   ____ a. a nonparasitic disease
   ____ b. a one-celled plant
   ____ c. a small roundworm or eelworm

8. Some plant diseases may be carried by insects, such as aphids.

   ____ a. True
   ____ b. False

9. Plant diseases pass through three stages. They are --

____ a. Inoculation, incubation and induction
____ b. Incubation, invasion, and completion
____ c. Inoculation, incubation, and invasion
____ d. Inoculation, incubation and protection

10. Pathogens include:

____ a. Nematodes
____ b. Fungi
____ c. Bacteria
____ d. All of the above

ANSWERS - LESSON 9

1. b
2. d
3. b
4. d
5. d
6. b
7. c
8. a
9. c
10. d

LESSON 10

[redacted] - [redacted]

A. INTRODUCTION

A weed is any plant (including a tree!) growing where it is not wanted. Weeds reduce crop yields, increase costs of production, and reduce the quality of crop and livestock products. In addition, some weeds cause skin irritation and hay fever, and some are poisonous to livestock and man.

Weeds harm desirable plants by:

- competing for water, nutrients, light and space.
- contaminating the product at harvest, and
- harboring pest insects, mites, vertebrates, or plant disease agents
- releasing toxic substances.

B. TERMS YOU NEED TO UNDERSTAND

How well do you know some of the terms that are important in the use of pesticides? Test your knowledge of them by writing down the definitions for the terms below. To check your answers, refer to the glossary.

1. Deciduous

2. Vascular Plant

3. Germination

4. Herbicide

5. Silvicide

6. Translocated

7. Defoliant

8. Desiccant

9. Allelopathy

C. Discussion

DEVELOPMENT STAGES

All plants have four stages of development:

- seedling -- small, vulnerable plantlets.
- vegetative -- rapid growth; production of stems, roots and foliage. Water and nutrient uptake and movement is rapid.
- mature -- little or no energy production or movement of water and nutrients.
- seed production -- energy directed toward production of seed. Uptake of water and nutrients is slow and is directed mainly to flower, fruit and seed structures.

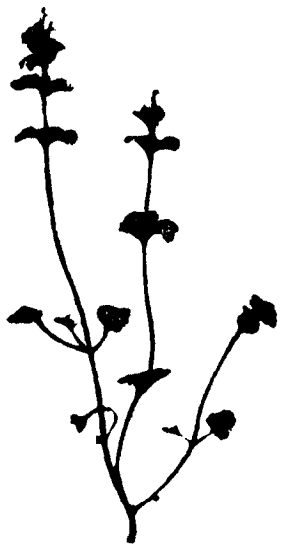
SOME COMMON FEATURES OF WEEDS

To control weeds, you need to know something about how they grow. An important feature is the length of their life cycle.

Annuals

Plants with a 1-year life cycle are annuals. They grow from seed, mature, and produce seed for the next generation in 1 year or less.

Summer annuals are plants that result from seeds that sprout in the spring. They grow, mature, produce seed, and die before winter.



Winter annuals are plants that grow from seeds that sprout in the fall. They grow, mature, and die before summer.

Biennials

Plants with a 2-year life cycle are biennials. They grow from seed and develop a heavy root and compact cluster of leaves the first year. In the second year they mature, produce seed, and die.

Perennials
Including woody plants

Plants that live more than 2 years, and may live indefinitely, are perennials. During the winter, they may lose their foliage and the stems of others may die back to the ground. Some grow from seed. More often reproducing by tubers, bulbs, rhizomes (below ground rootlike stems) or, stolons (above-ground stems) that produce roots.

Established perennial weeds are more difficult to control, with herbicides, because of the large reserves of stored energy in the root system that can support life after treatment.

rhizomes and stolons.

Simple perennials normally reproduce by seeds. But root pieces may produce new plants.

Bulbous perennials may reproduce by seed, bublets, or bulbs.

Weed Classification

Terrestrial Plants

Pest plants on land include grasses, sedges, broadleaves, and woody plants.

Grasses. -- Grass seedlings have only one leaf as they emerge from the seed. Their leaves are generally narrow and upright with parallel veins. Most grasses have fibrous root systems. The growing point on seedling grasses is sheathed and located below the soil surface. Some grass species are annuals; others are perennials.

Sedges. -- Sedges are similar to grasses except that they have triangular stems and leaves in whorls of three. They are often listed under grasses on the pesticide label. Some herbicides control grasses are weak on sedges.

Broadleaves. -- Broadleaf seedlings have two leaves as they emerge from the seed. Their leaves are generally broad, with netlike veins. Broadleaves usually have a taproot and a fairly coarse root system. All actively growing broadleaf plants have exposed growing points at the end of each stem and in each leaf axil. Perennial broadleaf plants may also have growing points on roots and stems above and below the surface of the soil. Broadleaves can be species with annual, biennial, and perennial life cycles.

Woody plants. -- Includes handwood and conifer species. Handwood species are usually broad leaf and deciduous. The plants are normally dormant during the winter, although root growth may begin before the leaves appear in the spring. Root growth may also continue past leaf drop in the fall. Conifers have needle or scale-like leaves and are usually evergreen, with foliage persisting for 2 or more years. Active growth (photosynthesis) can occur during mild periods throughout the winter months. Cambial growth lays down a new layer of woody material each year in both hardwood and conifer species.

Aquatic Plants

Aquatic plant pests include vascular plants and algae.

Vascular Plants

Many aquatic plants are similar to land plants having stems, leaves, flowers, and roots. Most act as perennial plants - dying back and becoming dormant in the fall and producing new growth in the spring. They are generally classified as:

- emergent (emersed) -- most of the plant extends above the water surface. Examples are cattails, bulrushes, arrowheads, and reeds.

- floating -- all or part of the plant floats on the surface. Examples are waterlilies, duckweeds, waterlettuce, and waterhyacinth.

- submergent (submersed) -- all of the plant grows beneath the water surface. Examples are watermilfoil, elodea, naiads, pondweeds and coontails.

Emergent and floating plants, like some land plants, have a thick outer layer on their leaves and stems which hinders herbicide absorption. Submergent plants have a very thin outer layer on their leaves and stems and so are very susceptible to herbicides.

Algae

Algae are aquatic plants without true stems, leaves, or vascular systems. For control purposes, they may be classified as:

- plankton algae -- microscopic plants floating in the water. Many multiply rapidly and cause "blooms" in which the surface water appears soupy green, brown or reddish brown.

- filamentous algae -- long, thin strands of plant growth that form floating mats or long strings extending from rocks, bottom sediment, or other underwater surfaces.

- a macroscopic freshwater algae -- large algae that look like vascular aquatic plants. Many are attached to the bottom and grow up to 2 feet tall; however, they have no true roots, stems, or leaves.

SELF TEST

AND

ANSWERS

LESSON 10

SELF TEST

1. Match the following:

____ a. Lives for several years	1. Biennial
____ b. Sprouts in the spring and lives for 1 growing season	2. Perennial
____ c. Lives for 2 years	3. Summer annual
____ d. Sprouts in the fall and lives for 1 growing season.	4. Winter annual

2. Plants that often reproduce from tubers, bulbs, rhizomes, or stolons are called:

____ a. Annuals
____ b. Biennials
____ c. Perennials
____ d. Summer annuals

3. A pesticide used to control brush and trees:

____ a. Avicide
____ b. Piscicide
____ c. Silvicide

4. As a rule perennial weeds are more difficult to control with herbicides than annual weeds because --

____ a. Annual weeds start growth earlier in the spring than do perennial weeds.
____ b. Perennial weeds are not sensitive to most pesticides.
____ c. Perennial weeds have large reserves of stored energy that can support life for a while after treatment.

5. Seedlings that have only one leaf as they emerge from the seed:

____ a. Broadleaves
____ b. Grasses
____ c. Woody plants

6. Plants that grow from seed, mature, and produce seed for a new generation in 1 year or less are:

____ a. Perennial
____ b. Annual
____ c. Both of the above

7. The direct or indirect effect of one plant on another through the production of chemical that affect the growth of the other plant is called:

____ a. Allelopathy
____ b. Cambral growth
____ c. Germination
____ d. Translocation

8. Similar to grasses except that they have triangular stems and three whorled leaves --

____ a. parasitic plants
____ b. algae
____ c. sedges

9. Seedlings that have two leaves as they emerge from the seed --

____ a. Broadleaf
____ b. Grasses
____ c. Sedges

10. Match the following on aquatic plants -

____ a. All or part of the plant floats	1. Submergent
____ b. Grows beneath the water surface	2. Floaters
____ c. Aquatic plant without a vascular system.	3. Emergent
____ d. Most of plant extends above water surface	4. Algae

ANSWERS - LESSON 10

1a. 2
b. 3
c. 1
d. 4

2. c

3. c

4. c

5. b

6. b

7. a

8. c

9. a

10a. 2
b. 1
c. 4
d. 3

LESSON 11

VERTEBRATE PESTS

A. INTRODUCTION

All vertebrate animals have a jointed backbone. They include fish, snakes, turtles, alligators, lizards, frogs, toads, salamanders, birds and mammals. Vertebrate pests are simply animals whose presence or activities conflict with human interests and well-being. What may be a pest animal in some situations may be a highly desirable animal in others.

B. TERMS YOU NEED TO UNDERSTAND

How well do you know some of the terms that are important in the use of pesticides? Test your knowledge of them by writing down the definitions for the terms below. To check your answers, refer to the glossary.

1. Vertebrate

2. Predacide

3. Habitat

4. Predator

5. Mammals

6. Avicide

7. Reptiles

8. Rodent

9. Rodenticide

10. Piscicide

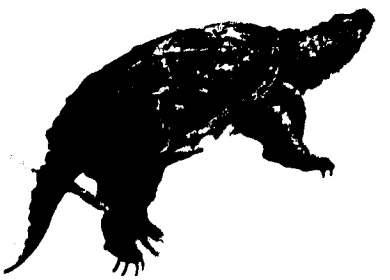
11. Ecosystem

C. DISCUSSION

Most vertebrate animals are not pests. Many are a necessary and an enjoyable part of our environment. A few vertebrate animals can be pests in some situations. Some, such as birds, rodents, raccoons, and deer, may eat or injure forest trees, crops, and ornamental plants. Birds and small mammals may eat newly-planted seeds. Birds and rodents consume stored food, but often contaminate and ruin even more than they eat. Birds and mammals such as foxes and coyotes, prey on livestock and poultry. In forestry reforestation activities, clipping and browsing of regeneration seedlings by rabbits, pocket gophers, deer, and elk are often serious problems.

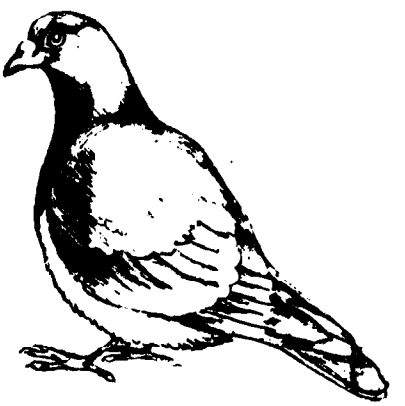
FISH

People have caused most fish problems by putting some species where they normally would not have been. We consider some fish to be undesirable because they are not useful for sport or food. Moreover, some undesirable fish compete with more desirable species. Some fish are intermediate hosts for parasites of man.



REPTILES AND AMPHIBIANS

Reptiles (snakes, lizards, turtles, and alligators) and amphibians (frogs, toads, and salamanders) may cause local problems. Although they may cause little damage, many people dislike or fear them. Snakes and turtles can create many problems in fish hatcheries or waterfowl production areas.

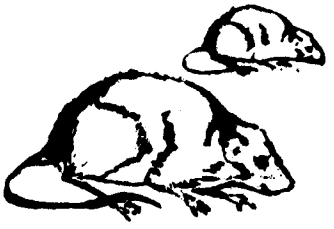


BIRDS

Bird damage is usually quite varied. It includes --

- structural damage by woodpeckers,
- destruction of feed, fruit, nut, grain, timber, and vegetable crops by seed- and fruit-eating birds,
- hazards to animal and human health caused by diseases spread by birds such as pigeons and parakeets,
- annoyance caused by birds roosting in or near dwellings.

Control of bird pests requires highly specialized knowledge and techniques. Many birds are protected by State and Federal laws and regulations. Contact your county agent before you undertake any bird control program.



MAMMALS

Damage by mammals is rather varied. Some cause serious health problems to livestock and humans. Diseased mammals may transmit to humans diseases such as rabies, plague, food poisoning, and tularemia. Killing of mammals is costly and in some instances, controversial. Some damage fruit, vegetables, nut, grain, range and tree crops. The damage they do to dams and ditches can be very costly. Mice and rats cost millions of dollars in damage each year. How do you tell what mammal caused the damage? You can eliminate some suspects if you know --

- which animals are found in your part of the country,
- what kinds of places they live in, and
- what their habits are.

Animal signs (tracks, droppings, toothmarks, diggings, burrows, hair, and scent) plus the type of damage will give you more clues.

CONTROLLING VERTEBRATES

The objective of any animal damage control program should be to control the damage and should be limited to offending pests or particular groups -- not to the species as a whole.

Exceptions to this general rule are made for rats and mice, which are usually overwhelmingly detrimental.

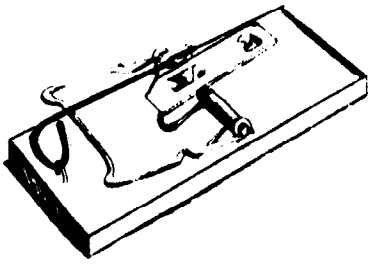
Wild mammal and bird populations are an important part of our natural ecosystem, but at times individuals of a certain species can trespass on human interests. When a rabbit damages garden crops, shrubs, or trees, it becomes a pest. When a coyote or domestic dog kills sheep, it becomes a liability. We should keep in mind that any control directed at one segment of the ecosystem can have effects on other components. For example, intensive predator control may lead to increased rabbit and rodent problems. The selective control of problem pests, or preventing damage by nonlethal means tends to minimize effects on the total ecosystem.

State and local laws may prohibit the trapping and killing of some animals such as birds, coyotes, muskrats, and beavers, unless you have a special permit. Always check with local authorities before beginning a control program.

Methods of vertebrate pest control include mechanical control, sanitation, and chemical control. These methods are reviewed in the following sections.

Mechanical Control

Mechanical control methods include traps, barriers, gunning, attractants, and repellents.



Traps

Traps are often used in vertebrate pest

control. Leg-hold traps have been traditionally used, but such traps are nonselective and often injure nontarget animals. Traps which, by design or location, quickly kill only target pests are more desirable. Traps should always be checked daily.

Barriers

Barriers are designed to prevent pests from passing through. Examples include fences, screens, and other barriers that cover openings, stop tunneling, and prevent gnawing. Materials used are sheet metal, hardware cloth, concrete, expanded metal, etc. This approach is often effective in control of rodents, bats, and birds in structures.

Gunning (Shooting)

Gunning, though selective, is expensive and time consuming. It works best in combination with other methods. Gunning will often take larger predators not controlled by traps or toxic devices.

Attractants

Techniques such as light and sound are used to attract pests to a trap. Predator calling is sometimes a part of gunning efforts against larger predators.

Repellents

These materials include a variety of devices designed to keep pests from doing damage. Automatic exploders, noise-makers, recordings of scare calls, moving objects, and lights are some of the repellents used. Another category of repellants is the nontoxic chemicals. These produce an undesirable taste, odor, feel, or smell. These may be applied to forest seedlings and other crops to protect from vertebrate pests.

Sanitation

Removing sources of food and shelter can help to suppress some vertebrate pests. Sanitation techniques are more often used to control rodents in and around homes, institutions, restaurants, food-processing facilities, and other related areas.

Chemical Control

Pesticides for rodent pest control usually are formulated in baits. The chemicals can be toxic in sufficient amounts to humans, livestock, and other animals. Therefore, correct bait placement is important to control the pest while protecting nontarget species. Thorough knowledge of the pest's habits is important.

Few pesticides are available for nonrodent vertebrate pest control, and many require special, local use-permits. The pesticides that are registered for this purpose are usually used as bait applications.

It is possible to use a broad-spectrum pesticide (a pesticide having an effect on several species) selectively; however, knowledge of the chemical and area's vertebrate species, along with their habits, is necessary. The program should also be carefully supervised.

The chemicals used to control vertebrate pests include rodenticides, piscicides (fish), avicides (birds), and predacides (predators). An integrated pest management approach is usually necessary for vertebrate pest control.

SELF TEST

AND

ANSWERS

LESSON 11

SELF TEST

1. Check a single feature that distinguishes or separates all vertebrates --

   ____ a. They lay eggs
   ____ b. They bear live young
   ____ c. They are warm blooded
   ____ d. They have backbones

2. Most pesticides are toxic only to the species being controlled.

   ____ a. True
   ____ b. False

3. One of the following is not a vertebrate animal --

   ____ a. Bluegill fish
   ____ b. Coyote
   ____ c. Rattlesnake
   ____ d. Honey bee

4. The most feasible control methods are those resulting in --

   ____ a. Maximum effect on the problem species
   ____ b. Minimum reduction of none problem species.
   ____ c. Least negative impact on related natural systems
   ____ d. All of the above

5. We should consider controlling a wild animal when it --

   ____ a. poses a public health threat
   ____ b. causes serious economic losses
   ____ c. becomes an unbearable nuisance
   ____ d. all of the above

6. Most fish problems have been caused by --

   ____ a. Nature
   ____ b. Birds carrying fish eggs
   ____ c. People

7. Many birds are protected by State and Federal laws and regulations.

   ____ a. True
   ____ b. False

8. Match the following:

____ a. Avicide	1. Feeds on insects and animals
____ b. Reptile	2. Place where an organism lives
____ c. Habitat	3. Used to control birds
____ d. Predator	4. Used for control of predator
____ e. Predacide	5. Controls fish
____ f. Piscicide	6. Snakes, turtles, and lizards

9. When trying to identify a specific mammal that is causing damage, you should know --

____ a. the animals that live in your area
____ b. the kinds of places in which they live
____ c. their habitat
____ d. their signs, such as tracks, droppings, toothmarks., etc.
____ e. all of the above.

10. Increased predator control often leads to --

____ a. decreased rodent and rabbit problems
____ b. increased rodent and rabbit problems
____ c. no affect on the rodent and rabbit problems

ANSWERS - LESSON 11

1. d

2. b

3. d

4. d

5. d

6. c

7. a

8a. 3
b. 6
c. 2
d. 1
e. 4
f. 5

9. e

10. b

GLOSSARY

Many of the words defined here have additional meanings. The definitions given here are related to pesticides, pests, and their control.

Absorption -- The process by which a pesticide is taken into a plant, animal, or the soil. plant absorption is through the leaves, stems, or roots; animals absorb through the skin, mouth breathing organs, stomach, or intestines. Compare this term to adsorption.

Acaricide -- A pesticide used to kill mites, spiders, and ticks.

Acute toxicity -- The adverse effects from a one-time exposure.

Adaptation -- The process whereby repeated exposures to small amounts of a chemical make the platn or animal tolerant of very much.

Adjuvant -- A substance added to a pesticide formulation or spray to make it work better. Examples: surfactant, emulsifier, penetrant, spreader, wetting agent, drift agent. Also called an additive.

Adsorption -- The process by which a material is held or bound to the surface of a soil particle or mineral. Clay and highly organic soils have a tendency to adsorb pesticides. Compare this term to absorption.

Allelopathy -- The direct or indirect effect of one plant on another through the production of chemicals that affect the growth of the other plant.

Antagonism -- Two or more things acting together so that the effect is less than the sum of the individual effects.

Avicide -- A pesticide used to control pest birds. Usually designed to only repel birds, not kill.

Benign tumor A harmless growth.

Bioaccumulation -- The storage of a chemical in some storage depot in the body, e. g. body fat, bone.

Biochemical -- A chemical that can be used by a living organism.

Bioconcentration -- The process in which a pesticide becomes concentrated in plants or animals. The chemical increases in concentration at each succeeding link in the food chain.

Cancelled -- A pesticide or use that is no longer registered as a legal use by the Environmental Protection Agency. Remaining stocks can be used by order of the Administration, EPA.

Carcinogen -- An agent that causes cancer.

Carcinogenesis -- To give rise to cancers.

Carbamate -- A family of pesticides which are chemically similar. They all attack a pest in the same way. Examples include carbaryl (Sevin) and carbofuran (Furadan).

Certified applicator -- An individual who is certified to use or supervise the use of a restricted-use pesticides covered by her/his certification.

Chemical name -- A scientific name forthe active ingredient in a pesticide that identifies the chemical, its composition and/or structure.

Chronic toxicity -- The adverse efects from many, many repeated exposures.

Common name -- A simple name (compared to the chemical name) of a pesticide accepted by the Pesticide Regulation Division of EPA. A pesticide with two or more brand names may have the same common and chemical names.

Compatible -- Two or more pesticides are said to be compatible if they can be mixed, and one does not affect the properties of the other

Contaminate -- To make impure or to pollute; the addition of an unwanted material, such as a pesticide, where it is not wanted.

Corrosive -- A substance that usually contains a strong acid or base which may burn the skin, eyes, and damage certain types of spray tanks and other equipment.

Coverage -- The spread of a pesticide over an area.

Deciduous plant -- A plant that lives two or more years and loses its leaves during the winter.

Defoliant -- A pesticide that causes the leaves of a plant to fall off without killing, or immediately killing, the plant. Generally used to facilitate mechanical harvesting. Compare to Desiccant.

Degradation -- The breakdown of a complex chemical into a less complex form; this process can result from the action of microbes, water, air, sunlight, or other agents.

Desiccant -- A pesticide that promotes removal of moisture from plants or insects. Desiccants are used mainly for preharvest drying of actively growing plants.

Dosage -- Refers to the rate for a given area in pesticide application. Also, used as a consistent measure in testing to determine acute and chronic toxicities. Dosage is usually expressed in milligrams per kilogram (mg/kg) or parts per million (ppm).

Dose-time relationship -- The combination of how much chemical one is exposed to and how often the exposure occurs.

Drift -- The movement of a pesticide spray or dust particles by wind and air currents from the target area to an area not intended for treatment.

Economic threshold -- It is a point in pest infestation where the application of control measures would return more money than the cost of the control.

Ecosystem -- The interaction of the living organisms of an area and their nonliving environment.

Emulsion -- A mixture in which one liquid is suspended (mixed up) as minute droplets in another liquid. Example: oil in water. Compare to invert emulsion.

Environment -- Our surroundings, including water, air, land, plants, people and other animals, and the interrelationships that exist among them.

EPA registration number-- A number assigned by EPA to a pesticide when it is registered. All pesticide labels must display this number.

Food chain -- A phrase that describes how all living organisms are linked together and depend on each other for food. Example: Plant eaters, plant and meat eaters, or meat eaters.

Foreign chemical -- A chemical that cannot be used by a living organism.

Formulation -- The pesticide product which may contain one or more active ingredients, a carrier, and other additives required to make it ready for sale.

Fungicide -- A pesticide used to kill fungi.

GPA (g.p.a.) -- Gallons per acre.

GPM (g.p.m.) -- Gallons per minute.

Germination -- Beginning of growth; as the beginning of growth from a seed.

Habitat -- The physical place where an organism lives.

Herbicide -- A pesticide used to kill or inhibit unwanted plants.

Host -- The plant affected by a pathogen in a disease.

Ingest -- To eat, swallow, drink, or in some other way take into the digestive system.

Infection -- The precesses involved in the establishment of a disease in a host organism.

Inorganic -- Those compounds that do not contain carbon.

Insect -- A small, invertebrate animal with three body regions and six jointed legs; may have two, four, or no wings.

Insecticide -- A pesticide used to prevent or destroy insects.

Inversion -- A condition resulting when the temperature increases with elevation from the earth's surface. A normal condition without an inversion is when the temperature decreases with elevation. During an inversion, the air does not rise or rises very slowly from the earth's surface.

Invert Emulsion -- The water is dispersed in the oil rather than the oil in the water. Example is salad dressing.

Kilogram (kg) -- A unit of weight in the metric system equal to about 2.2 pounds. 1 kg equals 1,000,000 mgs.

Label -- Printed technical information about a pesticide that is attached to or printed on the pesticide container.

Larva -- A young, growing insect in the stage of its life that starts when it hatches from an egg and ends when it develops into a pupa. In this early stage, the immature insect is wormlike or grublike and usually does not look like an adult. Many insects cause most or all of their damage as larvae.

LC 50 -- An expression of acute inhalation toxicity. It means lethal dose for 50 percent of animals tested.

LD 50 -- An expression of acute oral and dermal toxicity. It means lethal dose for 50 percent of animals tested.

Leaching -- The movement of a substance downward or out of the soil as the result of water movement.

Liter -- A unit of volume in the metric system equal to a little more than one quart.

Low volatile pesticide -- A pesticide that does not evaporate quickly at normal temperatures.

Malignant tumor -- A cancer.

Mammals -- Warm-blooded animals that nourish their young with milk; their skin is more or less covered with hair.

Metamorphosis -- A change in the shape, form (or structure), and size of an insect from the egg through the larvae and pupa to the adult.

Meter -- A unit of length in the metric system equal to about 39.37 inches.

Milligram (mg) -- A unit of weight in the metric system; about 28,500 mg equals one ounce. 1,000,000 mgs equal 1 kg.

Miticide -- A pesticide used to kill mites.

Molluscicide -- A pesticide used to kill and control slugs and snails.

Mutagen -- An agent that changes the DNA structure.

Mutagenesis -- To give rise to changes (mutations).

Natural chemcial -- A chemical made by natural processes.

Nematicide -- Most often a soil fumigant used to kill nematodes.

Neoprene -- A synthetic rubber often used to make gloves and boots that offer protection against most pesticides; also used for spray hoses.

No-effect level -- Any level of chronic exposure to a chemical that produces no observable adverse effect in test animals.

Nymph -- The early stage in the development of those insects that do not have a larvae stage.

One-hundred-fold margin-of-safety -- The safety factor given humans when translating animal data to humans.

Organic -- Compounds containing carbon.

Organochlorines -- A family of pesticides which are chemically similar - they all contain chlorine. They are generally very persistent as compared to carbamates or organophosphates. Examples include chlordane, lindane, and DDT.

Organophosphates -- A family of pesticides which are chemically similar - they all contain phosphorous. They are generally less persistent than the chlorinated hydrocarbon family. They act by inhibiting a blood chemical called cholinesterase. Examples include malathion, Diazinon, and parathion.

Orifice -- The opening in a nozzle tip through which a liquid is forced out as a stream or broken into a spray.

Pathogen -- Any disease-producing organism. Most pathogens are parasites.

Penetration -- The ability to get through leaf, stem, etc.; the process of entering.

Perennial -- A plant that normally lives for more than 2 years. Examples: Shrubs and trees.

Pesticide -- A chemical substance, compound, or other agent used to control, destroy, or prevent damage by, or protect something from, a pest.

pH -- A measurement scale used to express the acidity or alkalinity of a solution. Examples: a pH of 7, the value for pure distilled water, is regarded as neutral; a pH of 1 to 7 is in the acid range; and a pH of 7 to 14 is in the alkaline range.

Phytotoxicity -- Harmful (injurious) to plants.

Piscicide -- A pesticide used to kill fish.

Poison -- A chemical that is acutely toxic in very small quantities. (LD 50 of 50 mg/kg or less)

Potable water -- Water that is suitable and intended for human consumption.

Predacide -- A pesticide used to control vertebrate predator pests.

Predator -- An insect or other animal that attacks, feeds on, and destroys other insects or animals.

Pupa -- The resting stage of many insects. Many pupae spend this period in cocoons, from which they emerge as adults.

Registered pesticides -- A pesticide that is approved by the U.S. Environmental Protection Agency for use as stated on the label of the container.

Reptiles -- Vertebrate animals that are cold-blooded and possess scaly skin. Examples: snakes, turtles and lizards.

Residual pesticide -- A pesticide remaining in the environment for a fairly long time; the pesticide may continue to be effective for days, weeks, or months.

Residue -- The amount of pesticide that remains on or in a crop or animal or on a surface after treatment. Residues are usually measured in ppm (parts per million).

Restricted use pesticide -- A pesticide that has been classified, under provisions of FIFRA (Amended), for use only by an appropriately certified applicator.

Rhizome -- A root-like, underground stem.

Rodent -- Any animal in the order Rodentia. Examples: rats, mice, squirrels, beavers, woodchucks and gophers.

Rodenticide -- A pesticide used to kill or repel rodents.

RPAR -- Rebuttable Presumption Against Registration. A process used by EPA to identify pesticides that present "unreasonable adverse effects on the environment."

Sensitization -- The process by which a person becomes allergic to something.

Signal words -- Words that must appear on pesticide labels to show how toxic the pesticide is. The signal words are: "Danger-Poison" (for highly toxic), "Warning" (for moderately toxic), and "Caution" (for low order toxicity). The symbol of the skull and crossbones must appear on the labels of highly toxic pesticides (along with the words "Danger-Poison").

Silvicide -- A pesticide used to kill unwanted brush and trees.

Solution -- A combination of one or more substances with a liquid in which the ingredients are completely dissolved without changing their chemical characteristics. These will not settle out or separate in normal use. Example: sugar dissolved in water. Compare with Emulsion and Suspension.

Stage of development -- Time period during the growth from newborn or egg to adulthood. Example: An insect goes through many changes in its growth from and egg to an adult; the periods between stages of development.

Stolon -- A horizontal branch from the base of a plant. A stolon produces new plants from buds at its tip, also called a "runner".

Stylet -- A small, stiff, hyperdermic-like structure used by nematodes to pierce plant or animal tissue for the purpose of feeding.

Sufficient challenge -- The theory that exposure to very small amounts of foreign chemcials may stimulate the body's defense mechanisms, thereby making the body stronger.

Surfactant -- An adjuvant used to improve the emulsifying, dispersing, and spreading properties of a pesticide.

Suspended -- A pesticide that is no longer legal; the remaining stocks cannot be used. Compare to "Cancelled", which is less severe. Also to describes particles that are dispersed or held but not dissolved in a liquid.

Suspension -- A pesticide formulation consisting of very finely divided solid particles dispersed in a liquid. Compare to Emulsion and Solution.

Swath -- The width of ground covered by a sprayer when it makes one trip across a field or other treated area.

Synergism -- When the combined action of two or more pesticides is greater than the sum of their individual activity.

Synthetic chemical -- A chemical made in the laboratory or industrial plant.

Systemic -- A pesticide that is taken up by one part of a plant or animal and moved to another section where it acts against a pest. Example: a systemic insecticide can be applied to the soil, be taken up by a plant's roots, move into the leaves, and then control insects when they feed on the leaves.

Teratogen -- An agent that produces malformed offsprings.

Teratogenesis -- To give rise to malformed babies (monsters).

Threshold -- The highest no-effect level of a chemical. The dividing line between no-effect and effect levels of a chemical.

Tolerance -- The maximum amount of pesticide that may remain in or on raw agricultural products at the time of sale. Also, the ability of an organism to withstand unfavorable conditions, such as pest attacks, extreme weather, or pesticides.

Toxicology -- The science that studies the harmful effects of chemicals.

Trade name -- Same as brand name. The name given to a pesticide by the manufacturer to identify the product.

Translocated pesticide -- One that moves within a plant or animal after it has entered by some path. Systemic pesticides are translocated.

Vascular plant -- A plant that has specialized conducting cells, xylem, and phloem, that convey water and food.

Vector -- A carrier, such as an insect, that transmits a pathogen.

Vertebrate -- An animal with a bony spinal column. Examples: mammals, fish, birds, snakes, frogs or toads.

Volatile -- Evaporates at ordinary temperatures when exposed to air.

Volatility -- Describes how quickly and easily a liquid or solid evaporates at ordinary temperatures when exposed to air.